Details
of Quantifiable Objectives

CALFED
Agricultural Water Use Efficiency

December, 2000

Details of Quantifiable Objectives

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APPENDIX A.
Complete List of Potential Quantifiable Objectives by Sub-Region

Organization of Document

This document provides detailed information about CALFED's Agricultural Water Use Efficiency (Ag. WUE) element; it consists of the following six sections and appendix:

Section I. Conceptual Approach: An overview of Agricultural Water Use Efficiency Element of CALFED, including program background and a brief history of how the Agricultural Water Use Efficiency (Ag. WUE) element was developed. Also included are the program's purpose, conceptual approach, work completed to date and future expectations..

Section II. Explanation of Tables Used to Describe the Targeted Benefits and Quantifiable Objectives: A narrative of the development and listing of potential QOs. A complete listing of Targeted Benefits is in Section VI.

Section III. Water Balance and Flow Path Analysis: Background information on the water balance data used to determine QOs, and an explanation of the strategy used to determine irrigation system improvements at both the farm and district distribution level.

Section IV. Description of Detail Analysis: Detailed descriptions of how QOs are determined.

Section V. Hypothetical Examples of Local contribution to Quantifiable Objectives: Examples of how Proposal Solicitation Package (PSP) respondents can use this document to prepare their proposal.

Section VI. Glossary: A list of definitions, abbreviations and acronyms used in the document.

APPENDIX. Complete List of Quantifiable Objectives by Sub-Region: Appendix A contains a list of the completed and potential Quantifiable Objectives (QOs). To-date, 196 potential QOs have been identified. Of these, approximately 50 have been completed. WUE proposals that incorporate completed QOs will be given extra weight in the selection process.

Readily available data does not exist to allow completion of the remaining QOs. However, approximately 45 of the uncompleted QOs have been identified as high priority, and proposals that are linked to these priority outcomes (or Targeted Benefits) will also receive extra weight in the selections (although not as much weight as those that incorporate completed QOs).

Appendix A is organized into 21 chapters that correspond to the 21 Sub-Regions defined in the QO analysis. Each chapter contains background information and details as illustrated in Figure 1.1.

Figure 1.1. Organization of Appendix A

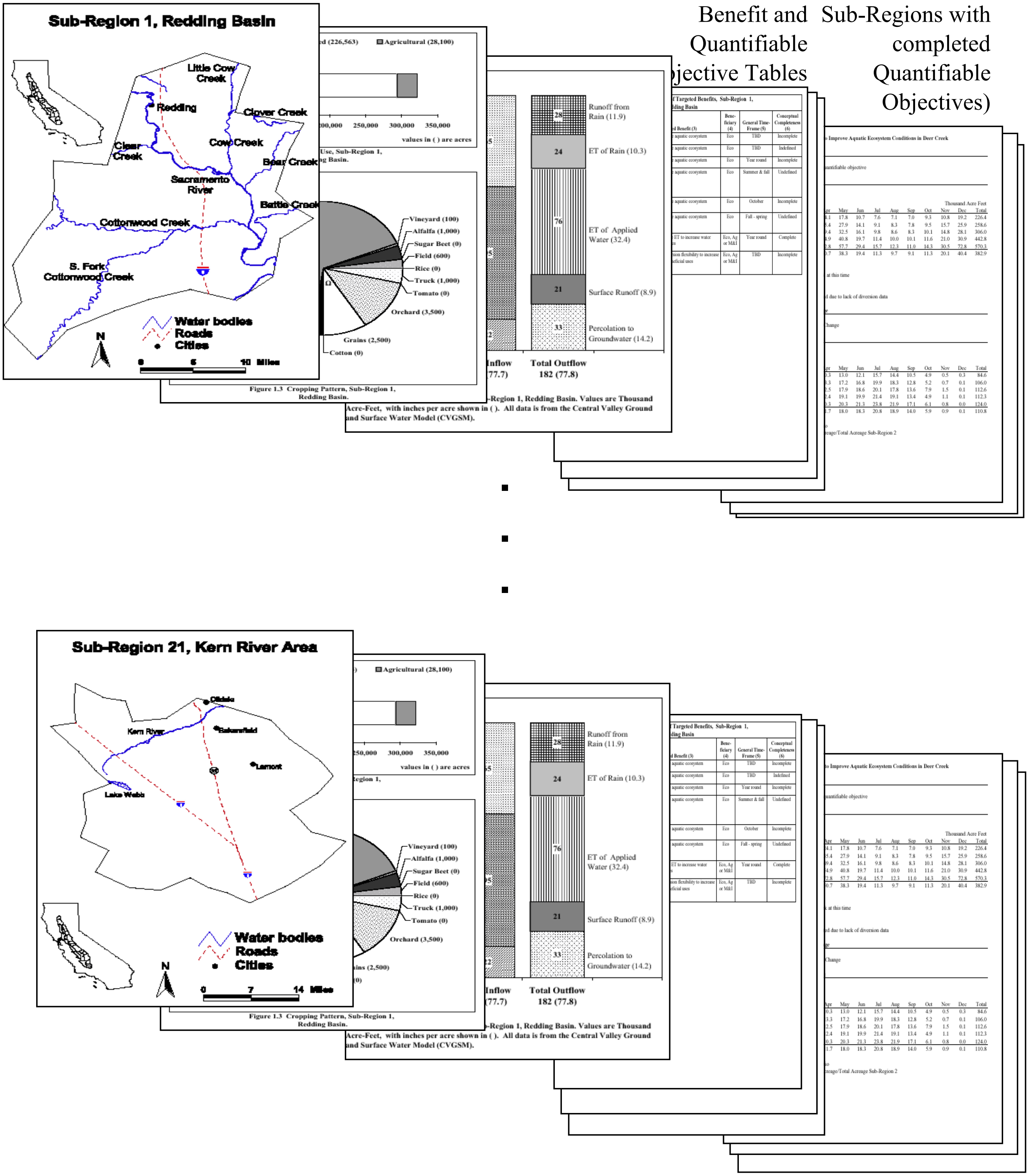
Separate Chapter for Each Sub-Region

Land Use and Cropping Patterns

Average Annual Water Balance

Targeted Benefit and Quantifiable Objective Tables

Quantifiable Objectives Detail Section (only for Sub-Regions with completed Quantifiable Objectives)



Section I.

Conceptual Approach

This section provides the background, purpose and conceptual approach to the development of Quantifiable Objectives. A detailed description of the derivation of Quantifiable Objectives is provided in Section IV.

Background

The CALFED Bay-Delta Program is a cooperative effort among state and federal agencies and the public to ensure a healthy ecosystem, reliable water supplies, good quality water and stable levees in California's Bay-Delta System. The CALFED Water Use Efficiency element – one of several CALFED Program elements - is a cornerstone of CALFED's water management strategy. This conceptual approach focuses solely on the agricultural component of the Water Use Efficiency element (Ag WUE).

CALFED's Ag WUE component has two primary elements: 1) encourage more water users and water suppliers to implement local cost-effective "Efficient Water Management Practices" (EWMPs); and 2) provide funding to foster the implementation of practices that are cost effective from a statewide perspective yet go beyond the locally cost-effective level. This document provides greater detail on the technical work underpinning CALFED's approach to fostering implementation beyond the locally cost-effective level.

The concepts and approaches articulated in this document have been developed with significant input from stakeholders and a Technical Team[1] assembled to support Ag WUE. Still, much of the technical work summarized in this paper is preliminary and may be revised as Ag WUE is implemented and new information is developed.

Purpose

The Ag WUE component is grounded in the belief that water use efficiency actions should be derived from objectives. CALFED also recognizes that incentive-driven water use efficiency actions, shaped by local creativity and know-how, are powerful tools for instituting meaningful changes in water management practices. Finally, CALFED believes it is appropriate to invest public funds in projects that provide public benefits.

These philosophies are at the root of the Ag WUE effort. The voluntary Ag WUE incentive program is committed to using incentives to motivate water suppliers and water users to institute practices that can most effectively and efficiently address regional or statewide objectives that are not cost-effective from a local perspective. The voluntary practices, to be proposed by locals,

[1] The Ag WUE approach has been developed by a multi-disciplinary Technical Team with expertise in water conservation, water quality, resource economics, irrigation engineering and local operations.

will be targeted at achieving region-specific, CALFED benefits[2] related to water quality, quantity and in-stream flow/timing.

To facilitate this effort, CALFED has developed numerical targets, expressed as acre-feet of water, for specified locations and times in each of 21 sub-regions. These 21 sub-regions are illustrated on the map of California's Central Valley presented in Figure 1.2. These numerical targets represent CALFED's initial estimates of the practical, cost-effective contribution irrigated agriculture can make to attain these identified benefits. These estimates, referred to as Quantifiable Objectives, are approximations and may be revised as more detailed information is developed.

Approach

The conceptual foundation of the Ag WUE Incentive Program rests on several key elements. Broadly speaking, the Incentive Program is structured to identify, quantify and link specific CALFED goals with practical on-farm and district distribution system water management actions. This approach has coined the terms Targeted Benefit and Quantifiable Objectives as part of a conceptual model to make the Incentive Program a relevant, credible program that can be implemented and measured.

Targeted Benefits

Targeted Benefits[3] (TB), represent a specific listing of CALFED-related goals that are believed to have a connection to agricultural water management practices. A Targeted Benefit can be considered a potential Quantifiable Objective; as data is developed, a Quantifiable Objective will be developed to address a portion of each Targeted Benefit. Based on its review of existing CALFED goals and discussions with stakeholder groups, Ag WUE has identified 196 Targeted Benefits that articulate specific objectives related to water quality, quantity and in-stream flow/timing. For example, the US Fish and Wildlife Service (USFWS) identified that anadramous fish need increased flows on the Stanislaus River at specific times. Because irrigation water is diverted from the Stanislaus River, reduction in irrigation losses can potentially provide increased flows.

Because the Central Valley is not monolithic in either its connections to CALFED objectives or its hydrology, we have developed smaller, more homogenous areas, referred to as sub-regions. As illustrated in Figure 1.2, there are 21 sub-regions, each associated with identified Target Benefits. Targeted Benefits were drawn primarily from existing CALFED documents, the State's Impaired Water Body list (303d) and discussions with local agricultural representatives. Tables 1.1 and 1.2 summarize the types of Targeted Benefits found in each of the 21 sub-regions; a more detailed listing of the Targeted Benefits is available in Appendix A. Although great effort was made to develop a comprehensive list of Targeted Benefits, this list will be updated as more and new information becomes available.

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[2] CALFED benefits refer to public benefits to the Bay-Delta that either have been or will be identified through the CALFED program.

[3] Targeted Benefits are synonymous with "Intended Outcomes" as described in CALFED's 2001 WUE Proposal Solicitation Package (PSP); see Section IV of this document for additional information on PSP preparation.

Figure 3. Sub-Region Boundaries
Central Valley Ground and Surface Water Model

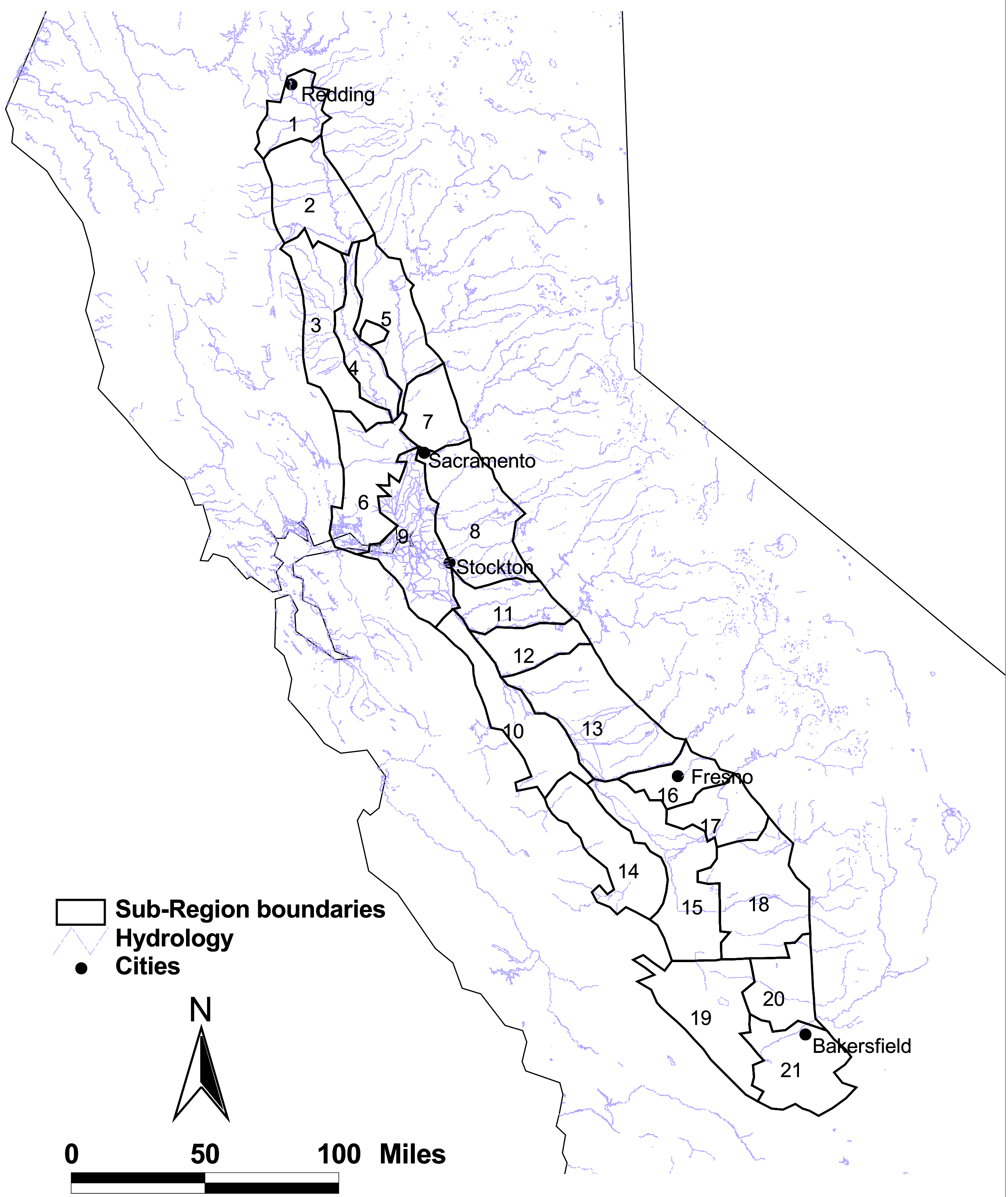


Table 1.1. Categories of Targeted Benefits by Sub-Region.

Targeted Benefits will be achieved by altering flow paths of irrigated agriculture.

Region		Sub-Region	Abbreviated Categories of Targeted Benefits											
				Quality							Quantity			
			Flow / Timing	Nutrients	Group A Pesticides	Pesticides	Salinity	Native Constituents	Temperatures	Sediments	Long-Term Diversion Fleüibility	Nonproductive Evaporation	Short-Term Diversion Fleüibility	Flows to Salt Sinks
Sacramento Valley	1	Redding Basin	✔								✔	✔		
Sacramento Valley	2	Sacramento Valley, Chico Landing to Red Bluff	✔			✔			✔		✔	✔		
Sacramento Valley	3	Sacramento Valley, Colusa Basin	✔		✔	✔	✔				✔	✔		
Sacramento Valley	4	Mid-Sacramento Valley, Chico Landing to Knights Landing	✔			✔	✔				✔	✔		
Sacramento Valley	5	Lower Feather River and Yuba River	✔		✔	✔	✔		✔		✔	✔		
Sacramento Valley	6	Sacramento Valley Floor, Cache Creek, Putah Creek, and Yolo Bypass	✔			✔					✔	✔		
Sacramento Valley	7	Lower Sacramento River below Verona	✔			✔	✔		✔		✔	✔		
Delta & Tributary	8	Valley Floor east of Delta	✔						✔		✔	✔		
Delta & Tributary	9	Sacramento - San Joaquin Delta	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔
West Side SJ Valley	10	Valley Floor west of San Joaquin River	✔		✔	✔	✔	✔		✔	✔	✔		✔
East Side SJ Valley	11	Eastern San Joaquin Valley above Tuolomne River	✔	✔	✔	✔	✔		✔		✔	✔		
East Side SJ Valley	12	Eastern Valley Floor between Merced and Tuolomne Rivers	✔		✔	✔	✔		✔		✔	✔		
East Side SJ Valley	13	Eastern Valley Floor between San Joaquin and Merced Rivers	✔		✔	✔	✔		✔		✔	✔		
West Side SJ Valley	14	Westlands Area								✔	✔	✔		✔
Southern SJ Valley	15	Mid-Valley Area									✔	✔		✔
Southern SJ Valley	16	Fresno Area	✔		✔	✔	✔		✔		✔	✔		
Southern SJ Valley	17	Kings River Area									✔	✔		✔
Southern SJ Valley	18	Kaweah and Tule River Area									✔	✔		✔
Southern SJ Valley	19	Western Kern County									✔	✔		✔
Southern SJ Valley	20	Eastern Kern County									✔	✔		
Southern SJ Valley	21	Kern River Area									✔	✔		✔

✔ represents 1 or more TB

Table 1.2. Detail of the Targeted Benefit categories presented in Table 1.

Abbreviated Category	Detailed Category
Flow / Timing	Provide flow to improve ecosystem conditions
Nutrients	Reduce nutrients to enhance and maintain beneficial uses of water (Eco, Ag, M&I)
Group A Pesticides	Reduce group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane [including lidane], endosulfan and toxaphene) to enhance and maintain beneficial uses of water (Eco, Ag, M&I)
Pesticides	Reduce pesticides to enhance and maintain beneficial uses of water (Eco, Ag, M&I)
Salinity	Reduce salinity to enhance and maintain beneficial uses of water (Eco, Ag & M&I)
Native Constituents	Reduce native constituents (selenium, boron, molybdenum, organic carbon) to enhance and maintain beneficial uses of water (Eco, Ag & M&I)
Temperatures	Reduce temperatures to enhance and maintain aquatic species populations
Sediments	Reduce sediments to enhance and maintain beneficial uses of water (Eco, Ag, M&I)
Long-Term Diversion Flexibility	Provide long term diversion flexibility to increase the water supply for beneficial uses (Eco, Ag, M&I)
Nonproductive Evaporation	Decrease nonproductive evaporation and transpiration to increase the water supply for beneficial uses (Eco, Ag, M&I)
Short-Term Diversion Flexibility	Provide short-term diversion flexibility to make water available to the Environmental Water Account in a timely manner
Flows to Salt Sinks	Decrease flows to salt sinks to increase the water supply for beneficial uses (Eco, Ag, M&I)

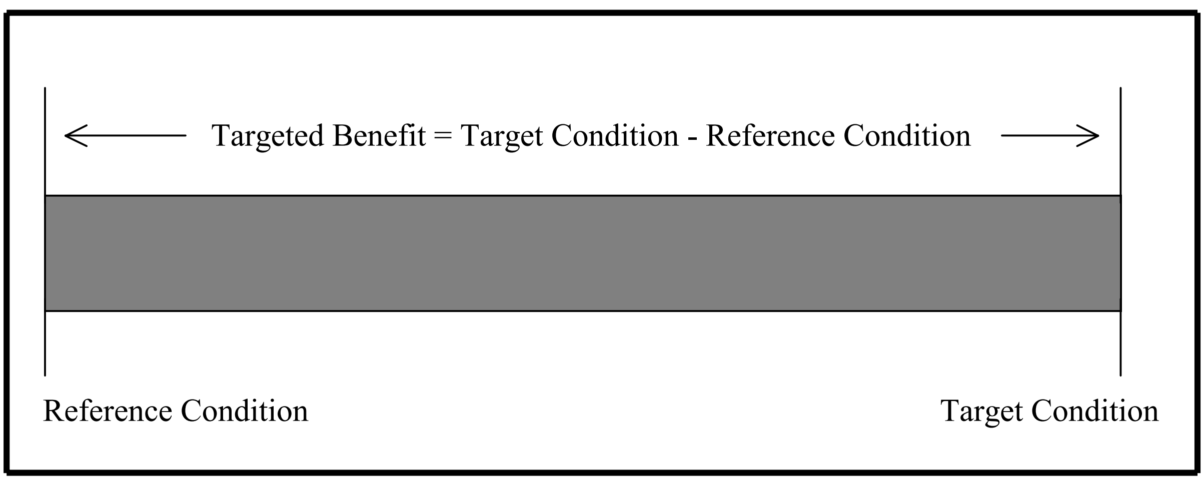
Quantifiable Objectives

Quantifiable Objectives (QOs) are the bridge between CALFED goals and local actions. As noted above, QOs represent CALFED's best estimate of the practical and cost-effective contribution agriculture can make towards achieving CALFED objectives. The primary source of data used to develop the QO is the U.S. Bureau of Reclamation's Central Valley Ground and Surface Water Model (CVGSM, 1990). Further detail on the CVGSM is provided in Section III.

In limited cases, irrigated agriculture could institute water management practices that achieve the entire Targeted Benefit. However, in most cases, irrigated agriculture will only contribute a portion of the benefits required to meet CALFED goals. A good example of the limited ability for irrigated agriculture to meet CALFED goals would be temperature targets on many of the rivers and streams in the Central Valley.

The process of developing QOs is a labor- and information-intensive effort. Targeted Benefits have been quantified by month, year type (wet, dry, etc) and sub-region (or river reach). The difference between the current condition (reference condition) and the target condition was computed for each month and year type to determine how much benefit is needed (Fig. 1.3). In some cases, there is not enough conclusive data to quantify the Targeted Benefit. In other instances, there is not a complete understanding of the cause-and-effect relationship between the Targeted Benefit (e.g., a particular flow rate) and the intended beneficiary, (e.g., decreased salmon smolt mortality). In these situations, CALFED intends to work closely with others, such as CALFEDs Ecosystem Restoration and Science programs, to develop more comprehensive data.

Figure 1.3. Targeted Benefit.

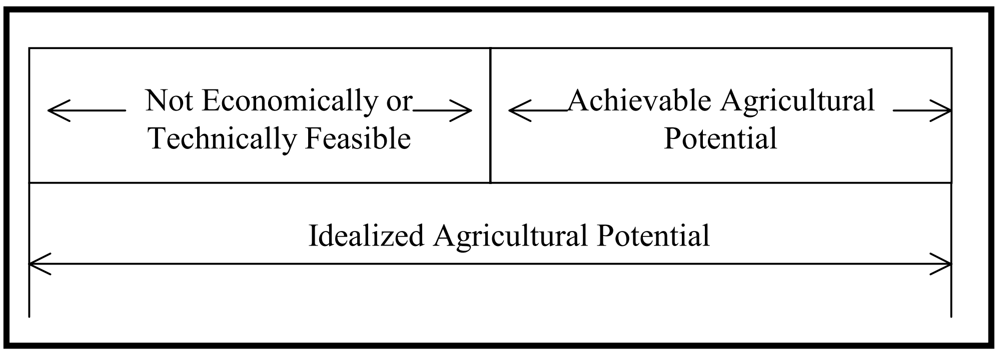


Sub-regional water balances have been determined to get a more complete understanding of the flow paths that affect a Targeted Benefit (see Section III.). The flow path approach is crucial to the analysis, because it helps us to understand how water moves through a given region and provides a first glimpse of the possible contribution irrigated agriculture could make to the

Targeted Benefit. The water balance information was also used to determine the Idealized Agricultural Potential.

The Idealized Agricultural Potential represents the contribution toward the Targeted Benefit that irrigated agriculture could make if it were irrigated perfectly with no losses or discharges (Fig. 1.4). It is important to note that such an idealized situation is not possible. However, we computed the Idealized Agricultural Potential to identify the outer bounds of irrigated agriculture's contribution. To more closely represent the practical contribution irrigated agriculture can realistically make, we reduced the Idealized Agricultural Potential by that portion that is not considered cost-effective or technically feasible. The portion that remains is the Achievable Agricultural Potential, which is the technically feasible, cost effective contribution towards the given objective. The Achievable Agricultural Potential is the water volume that can be used, on a monthly time step, to meet the Targeted Benefit. The relationship between the Idealized and Achievable Agricultural Potential is shown in Figure 1.4.

Figure 1.4. Relationship between the Idealized and Achievable Agricultural Potential.



The Achievable Agricultural Potential was compared to the Targeted Benefit to determine the Quantifiable Objective as illustrated in Figures 1.5a and 1.5b. Figure 1.5a. shows a situation where the Targeted Benefit is greater than what irrigated agriculture can contribute. In this case, all of the Achievable Agricultural Potential could be used and another source of benefits must be pursued in order to satisfy the Targeted Benefit. Figure 1.5b shows a situation where the Targeted Benefit is less than the Achievable Agricultural Potential. In this situation there are more benefits available than are needed to satisfy the Targeted Benefit.

Technical Work Completed

The Ag WUE Technical Team has worked for the past 18 months to refine the approach outlined above, gather the necessary data and begin developing a list of QOs. A core technical team is headed by Dr. Jack Keller, an Emeritus Professor of Irrigation Engineering at Utah State University and a widely respected expert in irrigation technology. Other core team members include Dr. Mark Roberson, a soil and water scientist, and Dr. Steve Hatchett, an agricultural economist. In addition to the core team, a panel of regional liaisons is consulted on an on-going basis. The regional liaisons include Marc VanCamp, Principal Engineer at MBK Engineers representing the Sacramento Valley, Joe Lima, Water Use Manager at Modesto Irrigation District representing the San Joaquin tributaries, Joseph McGahan, Principal Engineer at

Summers Engineering representing the westside and southern portion of the San Joaquin Valley and Grant Davids, Principal Engineer at Davids Engineering representing the lower Eastside and southern portions of the San Joaquin Valley.

Figure 1.5a. Quantifiable Objective when less than Targeted Benefit.

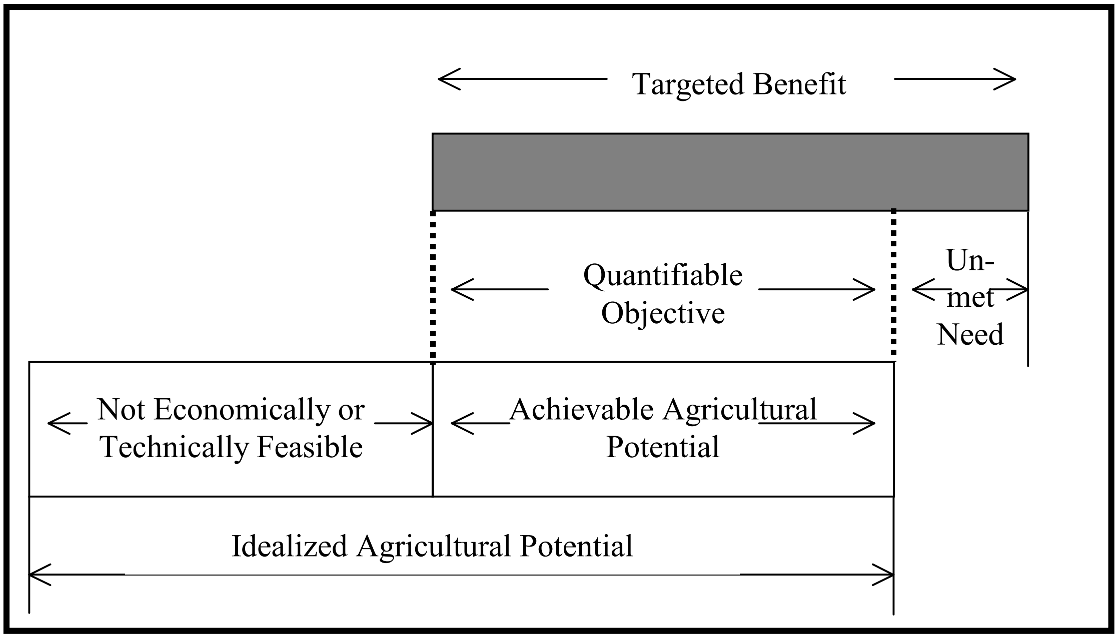
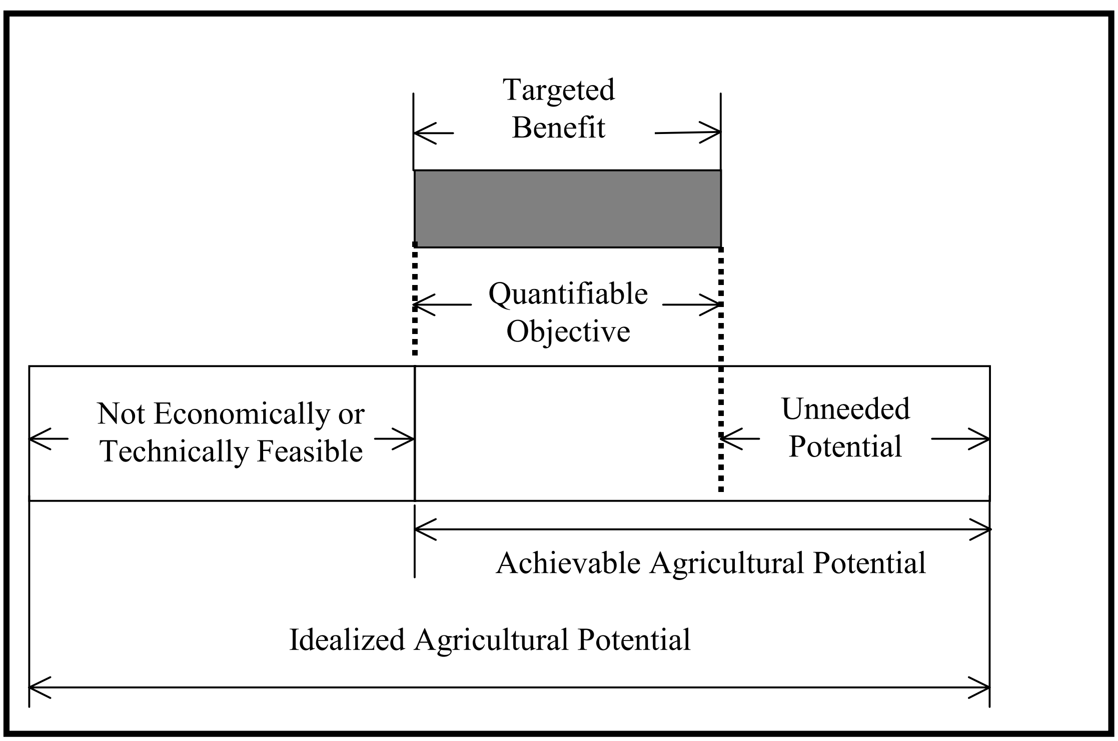


Figure 1.5b. Quantifiable Objective when equal to Targeted Benefit.



Working under the guidance of WUE Program Manager Tom Gohring, the Technical Team has vetted its work frequently with a stakeholder steering committee, the regional liaisons, and a range of experts familiar with the Bay-Delta ecosystem, water quality and related topics. Much work has been completed. Among the major accomplishments to date:

List of Completed Quantifiable Objectives: Approximately 55 Quantifiable Objectives have been completed (Table 1.3). Proposals that demonstrate potential progress toward these completed Quantifiable Objectives will receive extra weight in the proposal selection process. To make a strong linkage to a Quantifiable Objective, a proposal should include the Quantifiable Objective number and title, the actions or practices proposed for addressing the Quantifiable Objective and the intended quantitative progress towards the Quantifiable Objective for different conditions. Section V of this document provides an example of how such linkages can be demonstrated.

List of Priority Targeted Benefits: Approximately 40 Targeted Benefits have been identified as high priority by meeting all of the following criteria:

- A QO has not been completed for this Targeted Benefit.
- Although data may not be available to fully quantify either the existing condition or the target condition, sufficient information exists to indicate that their difference will result in a considerable quantified Targeted Benefit.
- Sufficient information exists to indicate that improvements in irrigation management could contribute to the Targeted Benefit even though data is not available to fully quantify the Achievable Agricultural Potential.

Although insufficient data is available to define Quantifiable Objectives for these Targeted Benefits, immediate progress in these areas is desired. Proposals that address these Priority Targeted Benefits will receive extra weight in the proposal selection process (but not as much weight as proposals demonstrating progress towards completed Quantifiable Objectives). Note, Priority Targeted Benefits were referred to as “Priority Outcomes” in the Proposal Solicitation Package (PSP).

List of Targeted Benefits: the Technical Team has prepared a list of 196 Targeted Benefits. This list represents those site-specific CALFED goals that appear to have a link with agricultural water management practices (See Appendix A.)

Sub-Regional Water Balances: Relying primarily on the Bureau of Reclamation’s Central Valley Groundwater and Surface Water Model (CVGSM), the Technical Team has developed preliminary water balances for each of the 21 sub-regions using monthly time steps for the five distinct water year types (Appendix A).

Expected Completion of Quantifiable Objectives: Table 1.5 shows the number of QOs currently under various stages of completion and the numbers expected in the foreseeable future.

Table 1.5. Current and Expected Status of Quantifiable Objectives.

Status		Expected June	
	Dec, 2000	2001	2003
Completed Quantifiable Objectives	55	70	111
Priority Targeted Benefits [1]	43	45	35
Not Completed [2]	98	81	50
Total	196	196	196

1: Insufficient data available to define QOs for these Target Benefits; however, immediate progress is desired in these areas.

2: Qualified data not available for reference condition, target condition or Achievable Agricultural Potential.

Section II.

Explanation of Tables Used to Describe Quantifiable Objectives

The tables provided at the end of this section are excerpts of Appendix A and are used to illustrate the format for reporting Quantifiable Objectives (QO). Although the excerpted tables (Tables A.11.1 through A.11.5) correspond to Sub-Region 11, their information is representative for all 21 Sub-Regions. The nomenclature for titles of these tables is shown, in Figure 2.1.

Figure 2.1. Key to Appendix A Table Titles.

Table A . 11 . 1

Indicates table type:
- 1 - Descriptive List of Targeted Benefits
- 2 - Quantified Targeted Benefits
- 3 - Quantified Targeted Benefit Change
- 4 - Quantifiable Objective
- 5 - Affected Flow Paths and Possible Actions

Indicates Sub-Region (1 through 21)

Represents Appendix A

Table Type 1 - Descriptive Lists of Targeted Benefits

Table 11.1 describes each Targeted Benefit including geographic location, probable beneficiary, timing and availability of quantitative data and conceptual completeness. The target benefits have been made as specific as possible, but where specificity is not available, or not possible, an explanation is given. The primary sources for the Target Benefit include CALFED's Ecosystem Restoration Program Plan (ERPP), the State Water Resources Control Board 303(d) list of impaired water bodies and discussions with Ag. WUE Senior Technical Advisors.

Column (1), TB #: uniquely identifies each Sub-Region's Targeted Benefits. In some instances, target benefits span more than one Sub-Region, hence the target benefit number of the corresponding Sub-Region is listed in brackets. For example, the target benefit given as TB 112 (Provide flow to improve aquatic ecosystem conditions in the San Joaquin River) spans two other Sub-Regions and is repeated as TB 131and TB 148.

Table Type 1 - Descriptive Lists of Targeted Benefits.

Table 11.1. Descriptive List of Targeted Benefits, Sub-Region 11, Eastern San Joaquin Valley above Tuolumne River					
TB # (1) [duplicate]	**Location (2)**	**Category of Targeted Benefit (3)**	**Bene-ficiary (4)**	**General Time-Frame (5)**	**Conceptual Completeness (6)**
112 [131, 148, 171]	San Joaquin River	Flow: Provide flow to improve aquatic ecosystem conditions	Eco	Fall	Incomplete
113	Stanislaus River	Flow: Provide flow to improve aquatic ecosystem conditions	Eco	Year round	Incomplete
121	Stanislaus River	Quality: Reduce pesticides to enhance and maintain beneficial uses of water	Eco or M&I	TBD	Complete
127	All affected lands	Quantity: Decrease nonproductive ET to increase water supply for beneficial uses	Eco, Ag or M&I	Year round	Complete
129 [110, 146, 160]	Wetlands	Quantity: Provide long-term diversion flexibility to increase the water supply for beneficial uses	Eco	Variable	Incomplete

Column (2), Location: refers to the specific place that a target benefit applies. If the location refers to a water body such as Stanislaus River (TB 113), without additional specificity, the Target Benefit applies to the entire portion of the water body that resides within the Sub-region.

Column (3), Category of Target Benefits: allows the Target Benefit list to be sorted by category.

Column (4), Beneficiary: is the intended recipient of the benefits of the given target benefit. The codes for the three beneficiaries are as follows:

- **Eco:** the ecosystem (fish flows, wetlands, etc.),
- **Ag:** agriculture (water quality, water supply), and
- **M&I:** municipal and industrial users (water quality and water supply).

Column (5), General Time-Frame: identifies the general time, either type of year or time of year, that a change in flow, water quality or quantity is needed to achieve the targeted benefit in order to have the intended affect on the beneficiary.

Column (6), Conceptual Completeness: describes our understanding of the cause and effect relationship between the target benefit in quantifiable water flow, timing, or quality terms, and the intended effect on the beneficiary. The primary source used to assign the Conceptual Completeness ratings for an ecosystem-related target benefit was CALFED's Ecosystem Restoration Program Plan. The Conceptual Completeness sources for the other target benefits were the best available data and technical judgment. The following three categories were used to describe the different levels of Conceptual Completeness:

1) **Complete:** the relationship between cause and effect is well known and achievement of a targeted benefit will result in the desired affect on the beneficiary. For example, for TB 127, (see Table 11.1, Decrease nonproductive ET to increase water supply for beneficial uses), we are confident that reducing evaporative losses will reduce irrecoverable losses and increase the amount of water available for beneficial uses.

2) **Incomplete:** the conceptual linkage between target benefit and the intended beneficiary has been established, but the cause and effect is not fully understood. For example, TB 113, (see Table 11.1, Provide flow to improve aquatic ecosystem conditions in the Stanislaus River) is conceptually incomplete as fisheries specialists are confident that improved flows will lead to improved aquatic ecosystems, but they are uncertain of the correlation between the amount of flow and ecosystem improvement.

3) **Undefined:** indicates that additional research and evaluation are required before a conceptual link can be made between the target benefit and the desired affect on the beneficiary.

Table Type 2 - Quantified Target Benefits

Table 11.2 provides the source and description of each quantified target benefit associated with Sub-Region 11. A quantified target benefit expresses the change in the existing condition that will be required to reach the targets related to flow/timing, quality or quantity terms assumed to be necessary to achieve the targeted benefit.

"Duplicate" Column (1), TB #: unique TB number used in all the following table examples.

Column (7), Source and Description of Quantified Targeted Benefit: provides the citation and text upon which the quantified target benefit is based. For example, TB 113 (Provide flow to improve aquatic ecosystem conditions in the Stanislaus River) was derived from the Ecosystem Restoration Program Plan (ERPP) through text that seeks to: "…maintain specified flow regimes: for example, provide the base flows in the Stanisluas River below Goodwin Dam in critical, dry, and below-normal years, minimum flows should be 200 to 300 cfs, except for a flow event of 1,500 cfs for 30 days in April and May." In addition, the core team suggests that there is a "…10 day October flow event of 1500 cfs." Columns 7 and 8 (see Table Type 3), use the following citation codes;

- **Calculated:** the given value is computed

- **Change given:** the Quantified Target Benefit Change

- **Core**: Ag WUE senior technical advisors: Regional Liaisons, Water Supply, Water Quality, and Biologists (personal communications, 1999 - 2000)

- **CVGSM**: Output or input data from the Central Valley Ground and Surface Model (CVPIA PEIS, 1999)

- **CVHJVIP:** Central Valley Habitat Joint Venture Implementation Plan, April 19, 1990 (CVHJVIP)

- **ERPP**: Draft Ecosystem Restoration Program Plan (June, 1999)

- **NA:** Data not available or not applicable

- **RWQCB:** Regional Water Quality Control Board

- **RWS (ICP):** Refuge Water Supply Interagency Cooperative Program (1998)

- **TBD:** To be determined

- **303(d)**: List of Impaired Water Bodies, 303(d) (State Water Resources Control Board, 1999)

Table Type 2 - Quantified Target Benefits.

Table 11.2. Quantified Targeted Benefits, Sub-Region 11, Eastern San Joaquin Valley above Tuolumne River

TB # (1) [duplicate]	Source and Description of Quantified Targeted Benefit (7)
112 [131, 148, 171]	ERPP: Manage flow releases from tributary streams to provide adequate upstream and downstream passage of fall-run and late-fall-run chinook salmon, resident rainbow trout, and steelhead and spawning and rearing habitat for American shad, splittail, and sturgeon.
113	ERPP: Maintain specified flow regimes: for example, provide the base flows in the Stanislaus River below Goodwin Dam in critical, dry, and below-normal years, minimum flows should be 200 to 300 cfs, except for a flow event of 1,500 cfs for 30 days in April and May. Core: Provide the following flows and water depths for all life stages of chinook/steelhead fish: 10 day flow of 1500 cfs in October, water depth of approximately 2 feet in spawning reach from Oct. through May.
121	303(d): Reduce diazinon to <0.04 ug L^{-1}
127	Core: Reduce unwanted ET by 7,500 acre-feet per year.
129 [110, 146, 160]	ERPP/ Core: Cooperatively manage ____ acres of ag lands and restore ____ acres of seasonal, semipermanent, and permanent wetlands consistent with the CV Habitat Jt Venture and N. Am. Waterfowl Mgmt. Plan.

Table Type 3 - Quantified Target Benefit Change

Table 11.3 provides information about some of the data used to develop the reference condition, quantified targeted benefit and quantified targeted benefit change associated with Sub-Region 11. The quantified targeted benefit change is the value of the required change, or improvement, in water flow, quantity, or quality at specific places and times, needed to achieve the targeted benefit.

"Duplicate" Column (1), TB #: unique TB number used in all the following table examples.

Column (8), Data Source: provides the citation for the data use in the Reference Condition, Quantified Targeted Benefit, and Targeted Benefit Change columns. The same citation codes (ERPP, Core, 303d, etc.) are used in these three columns as in Column 7 (see Table Type 2).

Reference Condition: is the quantitative representation of the current state of the water resource that must be affected to achieve the Targeted Benefit. For example, the Reference Condition for TB 113, see Table 11.3, provide flow to improve aquatic ecosystem conditions in the Stanislaus River) would be the existing flows in the Stanislaus River during specified times. The Data Source and Data Availability are provided for the Reference Conditions in Table 11.3. The numeric data are provided in the QO detail in Appendix A.

Quantified Targeted Benefit: is the numerically quantified expression of the given Targeted Benefit defined above. For Targeted Benefit 113 (see Table 11.3, provide flow to improve aquatic ecosystem conditions in the Stanislaus River), the Quantified Targeted Benefit is the desired flow condition(s). For critical, dry, and below-normal years, the base flows below Goodwin Dam should be 200 to 300 cfs, and there should also be a flow event of 1,500 cfs for 30 days in April and May. The Data Source and Data Availability are provided for the Quantified Targeted Benefits in Table 11.3. The numeric data are provided in the QO detail in Appendix A.

Quantified Targeted Benefit Change: is the flowtiming, quality or quantity change needed to achieve a given Targeted Benefit. The quantified change is determined in most cases by taking the difference between the reference condition and the quantified targeted benefit as follows:

Quantified Targeted Benefit Change = Quantified Targeted Benefit – Reference Condition

In addition to the Data Source and Data Availability, the range of annual values of Quantified Targeted Benefit Change are provided in Table 11.3 (see Column 10). The complete numeric data is provided in each QO's detail in Appendix A.

Columns (9), Data Availability: represents a summary of the availability of quantitative information for the reference condition, quantified, and quantified Targeted Benefit change. The following categories are used to describe data availability:

- **Not available**: quantitative data is nonexistent or severely limited in scope. For example, there are a few anecdotal references describing the linkage between irrigation management / temperature reduction temperatures and aquatic species population maintenance. However, these linkages have yet to be established through rigorous research or practice.

- **Insufficient**: data and studies have been cited, via conferences with Ag WUE technical specialists, but quantitative data has not yet been found.

- **Rough estimate**: quantitative data is available from various sources but is contradictory or unsupported by the broad scientific community. For example, TB 113 (Provide flows to improve aquatic ecosystem conditions) includes a range of base flows for various year types. Through conferences with aquatic ecosystem specialists, we have determined that these flow targets were developed as part of an adaptive approach that did not have a widely accepted scientific foundation.

- **Unproven – precise**: quantitative data exists, but no supporting documentation is available to justify precise quantitative values. For example, TB 125. (see Table 11.3, Reduce temperatures to enhance and maintain aquatic species populations) calls for less than 56 degrees Fahrenheit from October 15th to February 15th, and less than 65 degrees Fahrenheit from April 1st to May 31st. Although no supporting documentation has been provided for this temperature target, this is considered an accepted value among aquatic specialists.

- **Proven – precise**: precise quantitative values and supporting documentation are available for these targeted benefits. For example, TB 121. (see Table 11.3, Reduce pesticides to enhance and maintain beneficial uses of water in the Stanislaus River) calls for reducing the regulated pesticide Diazinon. In this case, the target concentration of Diazinon has been established and documented by the US EPA.

Table Type 3 - Quantified Target Benefit Change.

Table 11.3. Quantified Targeted Benefit Change, Sub-Region 11, Eastern San Joaquin Valley above Tuolumne River

	Reference Condition		Quantified Targeted Benefit		Quantified Targeted Benefit Change			
TB # (1) [duplicate]	**Data Source (8)**	**Data Availability (9)**	**Data Source (8)**	**Data Availability (9)**	**Data Source (8)**	**Data Availability (9)**	**Range of Values (10)**	**Specific Time-Frame (11)**
112 [131, 148, 171]	CVGSM	Unproven-precise	ERPP	Not available	Not available	Non-existant	Not available	Varies
113	CVGSM	Unproven-precise	ERPP	Rough estimate	Calculated	Rough estimate	31.1 - 170.6 TAF/yr	Year round
121	USGS Circ. 1159	Proven - precise	US EPA	Proven - precise	Calculated	Proven - precise (limited)	0-0.046 ug L^{-1}	Jan-Feb
127	CVGSM	Unproven-precise	Core	Rough estimate	Calculated	Rough estimate	7.5 TAF/yr	TBD
129 [110, 146, 160]	CVHJVIP	Insufficient	CVHJVIP	Uproven - precise	Not available	Insufficient	Not available	Not available

Column (10), Range of Values: provides a summary of the range of quantified target benefit change values. In most cases a range of values will be given. More detail on the derivation and range of values is provided in each QO's detail in Appendix A.

Column (11), Specific Time-Frame: identifies the specific year type and/or time of year that the quantified target benefit is needed (e.g. specific month(s), season(s), year type(s), etc.). For TB 123, (see Table 11.3, Reduce salinity to enhance and maintain beneficial uses of water), the specific timing is April through August and September through March.

Table Type 4 - Quantifiable Objectives

Table 11.4 provides information on the Achievable Agricultural Potential and the QO. The Achievable Agricultural Potential is the volume of water that irrigated agriculture can generate on a yearly basis after reducing irrigation system losses to a very low level. The information in Columns 12 and 13 is a summary of the analysis described in Section III.

"Duplicate" Column (1), TB #: unique TB number used in all the following table examples.

Column (12), Range of Achievable Agricultural Potential: is the volume of water available after decreasing the farm and district irrigation losses to a very low level using a cost-effective array of irrigation systems and management levels. This range is a summary of the values provided in QO's 113, 121 and 127 detail in Appendix A of this document. For Targeted Benefit 113, the achievable agricultural potential ranges from 147 to 256 TAF/year. The higher value in the range results from a higher level of investment in decreasing irrigation losses. The methodology used to determine values of the achievable agricultural potential for several months, year types, and investment levels is provided in Section IV.

Table Type 4 - Quantifiable Objectives.

Table 11.4. Quantifiable Objective, Sub-Region 11, Eastern San Joaquin Valley above Tuolumne River

TB # (1) [duplicate]	Achievable Agricultural Potential (12)	Quantifiable Objective (13)
112 [131, 148, 171]	TBD	
113	147.2 - 256.2 TAF per year	14[illegible] - [illegible]29.1 TAF per year
121	TBD	TBD
127	7.5 TAF/Yr plus additional water generated through reduction in application through improved irrigation systems	7.5 TAF/Yr plus additional water generated through reduction in application through improved irrigation systems
129 [110, 146, 160]	TBD	TBD

Column (13), Quantifiable Objective: represents the practical, cost effective (from a State-wide viewpoint) contribution that can be made to the given targeted benefit through changes in agricultural water management. The values presented in Table 11.4 provide a range of annual QO values. The complete numeric data are provided in the QO detail in Appendix A.

Table Type 5 - Affected Flow Paths and Possible Actions

Table 11.5 provides information about the flow paths that are affected by the quantified Targeted Benefit change and the achievable agricultural potential. Also in the table is a listing of the potential actions that may be implemented to achieve the quantified change.

"Duplicate" Column (1), TB #: unique TB number used in all the following table examples.

Column 14), Affected Flow Paths*:* A flow path is the course that water follows between entering and leaving a given water balance area. The flow paths considered in the QO methodology are shown in Figure 3.3. *Column (14)* indicates which flow paths would need to be changed to achieve the QO.

Column 15), Possible Actions: There are many possible ways to make the flow path changes described in *Column 14*. The possible actions listed in Column 15 are a sample of practices that growers or water suppliers could employ to generate the desired changes. These possible actions are only a sample and do not represent an exhaustive list of practices or prescriptive requirements.

Table Type 5 - Affected Flow Paths and Possible Actions.

Table 11.5. Affected Flow Paths and Possible Actions, Sub-Region 11, Eastern San Joaquin Valley above Tuolumne River

TB # (1) [duplicate]	Affected Flow Paths (14)	Possible Actions (provided as examples; proposers are encouraged to consider local actions that are not listed) (15)
112 [131, 148, 171]	TBD	TBD
113	Surface water return and Percolation to Groundwater	Improve farm irrigation management (such as irrigation scheduling) and more uniform irrigation methods (such as shorter furrows, sprinkler, or drip). Reduction in operational spill through improved management, canal automation or regulatory storage. Reduction in canal seepage through canal lining or piping.
121	TBD	TBD
127	ETAW	Reduce ET flows using improved irrigation methods, such as drip irrigation, and planting densities.
129 [110, 146, 160]	TBD	TBD

Section III.

Water Balance and Flow Path Analysis

This section provides the logic used to estimate the amount of water that can be generated by increasing irrigation performance from current levels to the highest cost-effective levels based on anticipated CALFED incentive support.

Water balances are analytical tools that are crucial to understanding existing conditions and potential water use efficiency improvements. The water balances used in the Ag WUE analysis include estimates of district and farm flow paths, in addition to conventional inflow, outflow, and storage components. The basic types of flow paths are atmospheric (precipitation and evaporation) and terrestrial (surface and subsurface flows). The actual paths that water follows are very diffuse, extensive, and complex, and can probably never be completely understood or quantified. This is especially true for field runoff and subsurface flows resulting from canal seepage and deep percolation. However, it is often quite adequate to use standard procedures coupled with local and expert judgment to estimate the destinies of inputs and outputs as specified at the district and farm levels.

The Ag WUE analysis is based on data from the Central Valley Groundwater Surface Water Model (CVGSM, 1990) to develop water balances for the 2I Sub-Regions of the San Joaquin and Sacramento Valleys of California. The CVGSM is based on hydrologic data for the 69-year period from 1922 through 1990 taken from USBR, USGS and DWR records. Covering an area of approximately 6.76 million acres of irrigated agricultural land, CVGSM's historical data is sorted into five water-year types (Critical, Dry, Below Normal, Above Normal, and Wet).

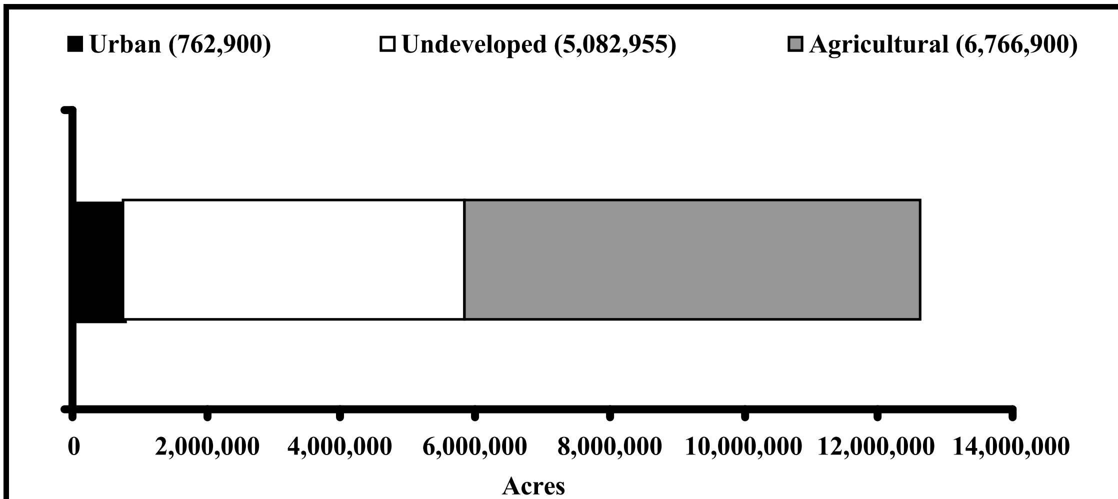
Figures 3.1 and 3.2 show the average land use and cropping patterns contained in the CVGSM. The CVGSM data was used because it is a comprehensive hydrologic model that treats land and water use groundwater flow and surface water flows in each of the Central Valley's 21 sub-regions in a consistent manner.

Figure 3.3 illustrates the inflow and outflow components (flow paths) of the water balance. Figure 3.4 shows the average year water balance for the Central Valley. The values for each flow path are given in both million acre-feet and inches (i.e., acre-inches per acre). Table 3.1 lists the values for all flow paths in all sub-regions.

The inflows include Rain, Surface Water Diversions, Imports and Groundwater pumping. Rain is based on the precipitation over the irrigated acreage. Surface Water Diversions are made by districts or riparian diverters, who take water from surface sources such as the Stanislaus or Merced River, and are eventually delivered to the farm. Imports include any water that enters a sub-region through a trans-regional canal, such as the Delta-Mendota Canal. Imported water that enters a sub-region, but is not used within that sub-region, is counted on the outflow side of the water balance as an Export. Groundwater pumping is from groundwater sources and is assumed to be primarily a farm-based activity.

The outflows include evaporation, runoff from Rain, evapotranspiration (ET) of rain, ET of applied water (ETAW), surface runoff, exports and percolation to groundwater. Evaporation and ET components are considered irrecoverable flows because naturally lost to the atmosphere. Direct runoff from rain is also considered irrecoverable because it is coming from an uncontrollable source during the non-irrigation season. Recoverable out flow paths include surface runoff and percolation to groundwater. These outflows go to sources that in many cases are considered inflows in other Sub-Regions. Recoverable flow paths can be rerouted but provide no new overall water quantity. Reducing irrecoverable flow paths will result in an overall increase in water quantity. On a sub-regional basis, the difference between inflows and outflows is less than one-inch per acre in all Sub-Regions.

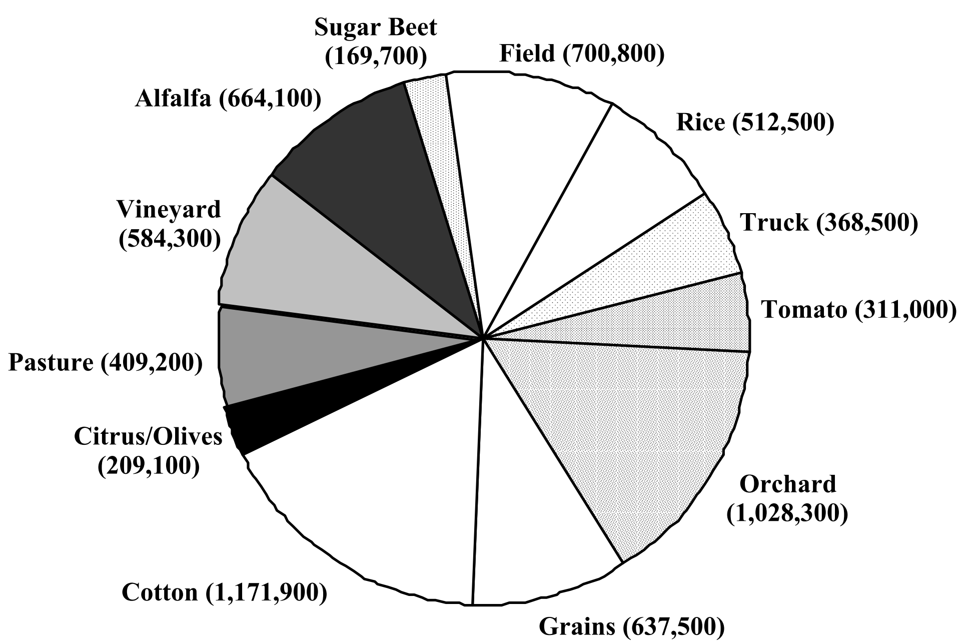
Figure 3.1. Land use, 1990, Central Valley.



source: CVGSM

values in ( ) are acres

Figure 3.2. Cropping pattern in the Central Valley.



source: CVGSM

values in ( ) are acres

Figure 3.3. Water Balance – Flow Path Elements.

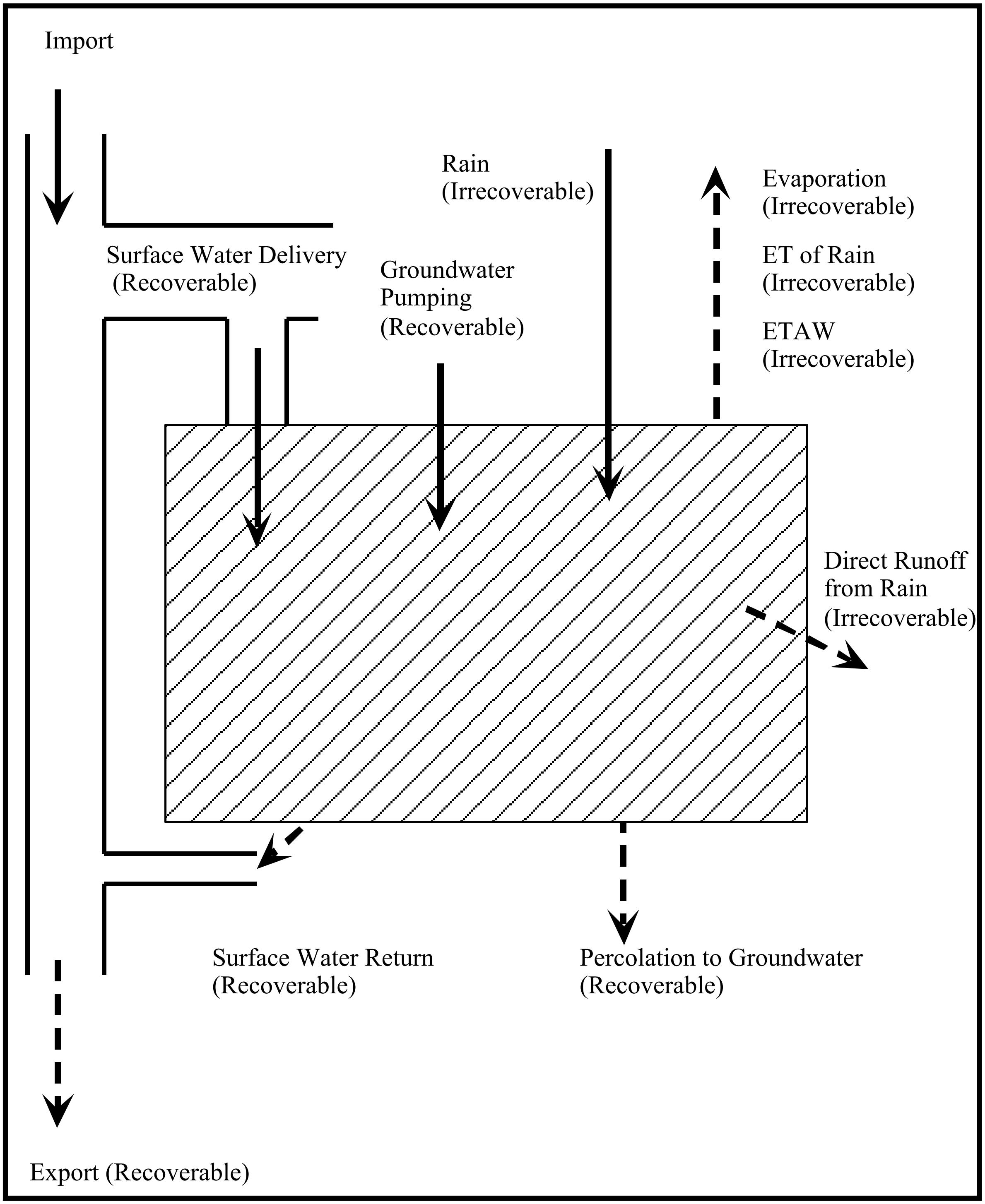
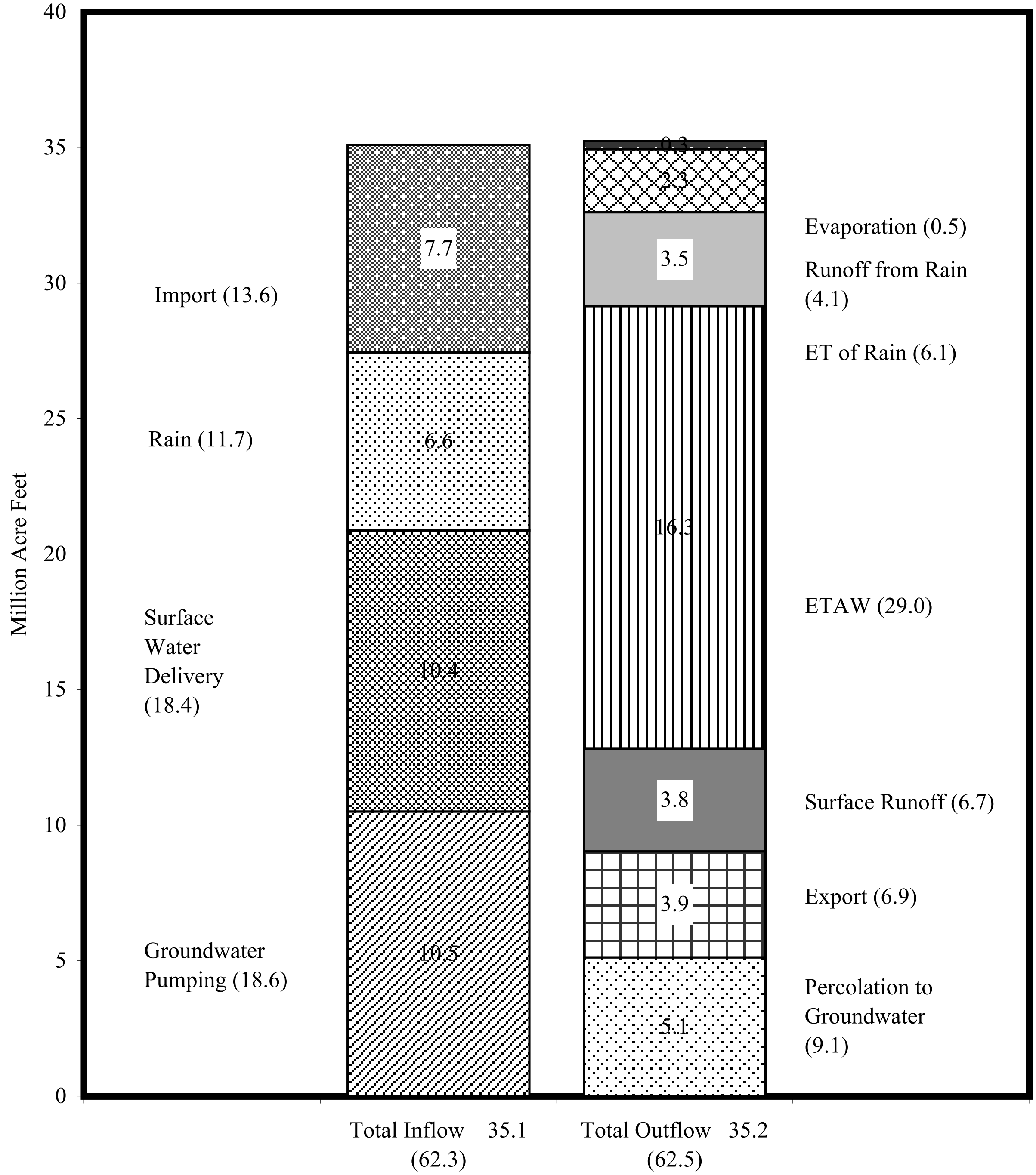


Figure 3.4. Central Valley Water Balance.



Central Valley Water Balance, Average Year". Values are Million Acre-Feet, with inches per acre shown in ( ). All data are from the Central Valley Ground and Surface Water Model (CVGSM).

Table 3.1. Sub-Regional Flow Path Elements for Weighted Average Year.

Sub-Region	Inflow: Rain	Inflow: Surface Water Delivery	Inflow: Groundwater Pumping	Inflow: Import	Outflow: Export	Outflow: Evap.	Outflow: ET of Rain	Outflow: ETAW	Outflow: Runoff from Rain	Outflow: Surface Runoff	Outflow: Percolation to Groundwater
	Thousand Acre-feet				Thousand Acre-feet						
1	65	99	22	0	0	1	24	76	28	21	33
2	325	1,143	483	5	988	2	138	437	126	59	182
3	486	844	337	427	23	19	232	992	223	222	369
4	414	928	330	0	228	10	190	632	193	325	76
5	619	1,213	531	84	102	7	240	1,089	300	240	441
6	353	260	463	88	0	8	183	570	140	165	127
7	144	79	278	273	101	10	74	303	55	134	124
8	392	57	735	183	0	14	166	664	204	268	60
9	591	1,314	161	57	331	2	213	917	288	70	291
10	288	200	483	1,184	32	52	163	1,080	103	592	176
11	192	1,537	130	622	1,134	7	102	531	3	245	418
12	212	586	248	470	433	9	121	523	71	242	113
13	460	116	985	680	6	30	276	1,332	141	322	163
14	223	0	726	903	0	27	182	1,190	2	0	470
15	353	464	1,453	290	0	21	242	1,611	89	417	236
16	130	0	207	328	0	14	85	379	31	126	43
17	286	803	481	41	372	5	159	593	82	181	195
18	556	392	1,126	583	6	18	305	1,382	196	37	720
19	125	0	355	606	0	18	97	691	14	0	303
20	130	0	336	340	0	13	93	480	20	78	135
21	229	330	634	498	154	12	170	869	19	43	446
	Million Acre-feet				Million Acre-feet						
Sub-Total	6.6	10.4	10.5	7.7	3.9	0.3	3.5	16.3	2.3	3.8	5.1
			Total Inflow	35.1						Total Outflow	35.2

Section IV.

Description of Quantifiable Objective Details

This section provides a step-by-step description of the methodology used to determine Quantifiable Objectives (QOs). This section is organized into a general description of the eight steps used to compute QOs and more detailed descriptions of the computations of three QOs that represent unique refinements to these general steps.

COMPUTATIONAL STEPS COMMON TO ALL QOs

The following eight general steps were used to compute all QOs. Some refinements to these steps were made for different types of Quantifiable Objectives. These refinements are presented later is this section.

Step 1. Quantified Targets
Step 1 provides quantified Targeted Benefit values by month and year type. The quantified target provides a numerical value of "where we want to get to" in terms of desired flow or water quality conditions.

Step 2. Reference Conditions
The reference conditions are the existing quantified conditions of the constituent, flow or water supply requirements that is being targeted. For example, the reference conditions for flow and timing Targeted Benefits are the flows in the targeted river reach for each month for each of the five water-year types (critical, dry, below and above normal, and wet).

Step 3. Quantified Targeted Benefit Changes
The quantified Targeted Benefit changes are the estimated water flow or quantity changes required to obtain the Targeted Benefit. They are the flow volume differences between the quantified Targeted Benefit (Step 1) and the reference conditions (Step 2) for the targeted river reach during each month for each of the five water-year types:

Quantified Targeted Benefit Changes = Quantified Targeted Benefits – Reference Conditions

Step 4. Area Affected by Targeted Benefit
In some cases the area that affects a Targeted Benefit is only a portion of the given sub-region. For example, a specific Targeted Benefit may be related to creek or river that only serves a portion of the sub-region, but there is no specific (or exclusive) flow path data for the irrigated area supplied from the creek or river. In these cases it is necessary to estimate the flow path values by proportioning the data from the entire sub-region by the ratio of the surface water diversions for each month and year-type:

Diversion Ratios = Creek or River Diversions ÷ Total Sub-Region 11 Stream Diversions

Step 5. Water Balance - Flow Path Elements
Flow Paths are the courses that water follows between entering and exiting a given irrigation service area. Physically, the sum of the entering water flow paths plus (or minus) any changes in soil or groundwater storage must equal the sum of the exiting water flow paths. This relationship is called the "water balance". The entering flow paths available from the CVGSM are: surface water diversions, imported water, groundwater diversions, and rain. The exit flow paths available from the CVGSM are: farm runoff and ET from rain, ETAW, export, surface runoff, percolation to groundwater, and evaporation from water surfaces.

These paths are used in the methodology for estimating the QO and they are provided for each month and for each of the five year-types in the set of Tables contained in Step 5. However, for Targeted Benefit areas that are subsets of a given sub-region, the flow path values must be proportioned using the diversion ratios from Step 4 as follows for each month of each water-year type:

Targeted Ag Service Area Flow Path Value = (Diversion Ratio) x (Sub-Region Flow Path Value)

An overall water balance check is made to provide a means for evaluating the consistency of the data by subtracting the sum of the outflows from the sum of the inflows for the portion of the Sub-Region that contributes to a given Targeted Benefit as follows:

Water Balance Check = Sum of Prorated Inflows – Sum of Prorated Outflows

The method also includes and applied water ratio, which is the ETAW divided by the sum of the irrigation water supplied. The applied water ratio provides a quick means for assessing the general level of irrigation performance within the Sub-Region under consideration, and is computed as follows:

Applied Water Ratio =Prorated ETAW ÷ Sum of Prorated Irrigation Water Inflows

Step 5 also includes a check of the existing balance between groundwater inflow and groundwater pumping for irrigated agriculture. This is done to provide a check on the sustainability of present groundwater usage and a means for evaluating the effects of increasing the applied water ratio through irrigation system improvements on extraction sustainability. It is also useful as a baseline for evaluating the potential for seepage recovery or conjunctive use. It is computed as follows:

Groundwater Check = Percolation to Groundwater – Groundwater Pumping

Step 6. Idealized Agricultural Potential
This Step provides the maximum amount of water available if irrigated agriculture were perfect, that is if ETAW is equal to all of the diverted water. This idealized potential, although impossible to achieve, is computed to provide the theoretical outer bound of the contribution that irrigated agriculture can make toward the Targeted Benefit without reducing ETAW. This bookend value is computed as the sum of all flow paths that can affect the Targeted Benefit.

The first step in this process is to make an export water adjustment where appropriate for a flow and timing related Targeted Benefit. However, for some sub-regions it is assumed that none of the export water is carried as part of the specific creek or river flows associated with the specific agricultural service area. In such cases there is no export adjustment.

The idealized agricultural potential is computed as the sum of the surface water diversions, import, and percolation to groundwater plus the export water adjustment (see above paragraph), minus ETAW and export water:

Idealized Ag Potential = Surface Water Diversions + Groundwater Pumping + Import Water + Export Adjustment – (ETAW + Export Water)

Step 7. Achievable Agricultural Potential

The achievable agricultural potential is the portion of the idealized agricultural potential that could be achieved by implementing practical hardware and management changes at both the farm and district levels. The achievable agricultural potential for a given area is based on an evaluation of the relative costs of changing the average estimated applied water ratio, or conversely, a loss fraction from its existing level to an improved level. To move to the targeted loss fraction requires a combination of management and hardware changes.

Since unwanted outflows occur at both the district and farm levels, the applied water ratio and loss fractions are stated in terms of the farm, district, or a combination of the two. The strategies for developing the loss fractions are based on the economics of improving irrigation management and are explained below.

Farm Level Improvements: Cost estimates used in this document are based on a study of irrigation costs and performance in the Central Valley of California prepared by CH2MHill for the U.S. Bureau of Reclamation. The study was initially completed in 1988, and was last updated in 1994 for use in the CVPIA Programmatic Environmental Impact Statement (CH2MHill, 1994). The study summarized the water use and costs of various irrigation systems used on major crops. For each crop category there is a set of feasible irrigation systems that are defined by combinations of hardware and management. Each system's water use is broken into consumptive use (ET), surface water return, groundwater return, and other evaporative flows.

To estimate the potential change in farm irrigation system loss the eleven crop categories in the CVGSM were consolidated into four major categories forage, field, truck, and orchard. These crop categories were based primarily on similarity of irrigation management and water use. For example, vineyards were grouped with orchards and tomatoes were grouped with truck crops. Table 4.1 lists the major crops included in each category. For each crop category, the set of feasible irrigation systems was narrowed to a set of cost-effective systems, representing the least-cost system to achieve a target loss fraction. The loss fraction is the proportion of applied water that is lost to evaporation, and surface and groundwater return.

Within each of the four crop categories there were six or seven potential irrigation systems that are used with the crop category. The crops and irrigation systems are summarized in Table 4.1. Figure 4.1 shows an example of the cost versus irrigation system loss for orchard crops. The cost curve shows the estimated additional annual cost per acre-foot of reducing farm irrigation losses. As the loss fraction decreases the cost of the irrigation system increases. The procedure for estimating the cost of farm irrigation system improvements is described in the following steps:

Table 4.1. Crop Categories and Irrigation Systems Used.

Crop Category	Major Crops in Category	Irrigation Systems
Forage	Alfalfa, Pasture	Border, Low Management Border with Tailwater Recycling, Low Management Border, Medium Management Border with Tailwater Recycling, Medium Management Border with Tailwater Recycling, High Management Lepa, High Management
Field	Cotton, Corn, Grains, Rice, Sugarbeets	1/2-mile Furrow, Low Management 1/2-mile Furrow, Medium Management 1/2-mile Furrow with Tailwater Recycling, Medium Management 1/2-mile Surge, High Management 1/4-mile Surge, High Management Lepa, High Management Subsurface Drip, High Management
Truck	Tomatoes, Truck	1/2-mile Furrow, Low Management 1/2-mile Furrow, Medium Management 1/2-mile Furrow with Tailwater Recycling, Medium Management 1/2-mile Surge, High Management 1/4-mile Surge, High Management Lepa, High Management Subsurface Drip, High Management
Orchard	Orchard, Vineyard, Citrus and Olives	Border, Low Management 1/2-mile Furrow, Medium Management 1/2-mile Furrow with Tailwater Recycling, Medium Management Border, High Management 1/4-mile Surge, High Management Surface Drip, High Management

1) The existing loss fraction for each crop category within a region was estimated from data gathered by the Department of Water Resources for Bulletin 160. The existing mix of irrigation systems was selected from the cost-effective set that would produce the average existing loss fraction for the crop category.

2) A reasonable mix of irrigation systems was selected to achieve a targeted loss fraction. This procedure depended on the type of Targeted Benefit being considered. To date, irrigation system costs have been estimated to achieve the following kinds of Targeted Benefits:

    a) Evaporation reduction benefits were analyzed by assuming that savings would be achieved by increasing the proportion of surface and subsurface drip irrigation on eligible crops. Eligible crops included orchards, vineyards and truck crops. These crops were deemed eligible because their yield and profit potential are considered sufficiently high to support the cost of system conversion. The analysis assumed that drip irrigation would be installed on 30 percent of the irrigated acreage of these eligible crops and ET would be reduced by 10 % on the converted acres.
    b) Flow/timing benefits were analyzed assuming that reductions in surface water diversion can provide these types of benefits. The irrigation system cost and efficiency estimates described above were used to construct cost curves for each crop category. Each cost curve began at the loss fraction associated with the estimated existing mix of systems. The mix of systems was then changed in a way that would decrease the overall loss fraction in a near-cost-minimizing fashion. Strict cost-minimization would lead to only one or two systems for the entire region. However, a larger number of systems more reasonably reflect the heterogeneity in growing conditions and the gradual adoption of new technologies. Nevertheless, as the overall average loss fraction approaches the minimum achievable, system options become reduced to only those one or two most expensive. As a result, each cost curve exhibited a moderately increasing range, an "inflection point" (where lower-cost adjustments have been exhausted), and a rapidly rising range. Figure 4.2 shows an example of the cost curve for orchard crops in Sub-Region 11.

Figure 4.1. Farm Loss Fraction and Costs, Orchards in the San Joaquin Valley.

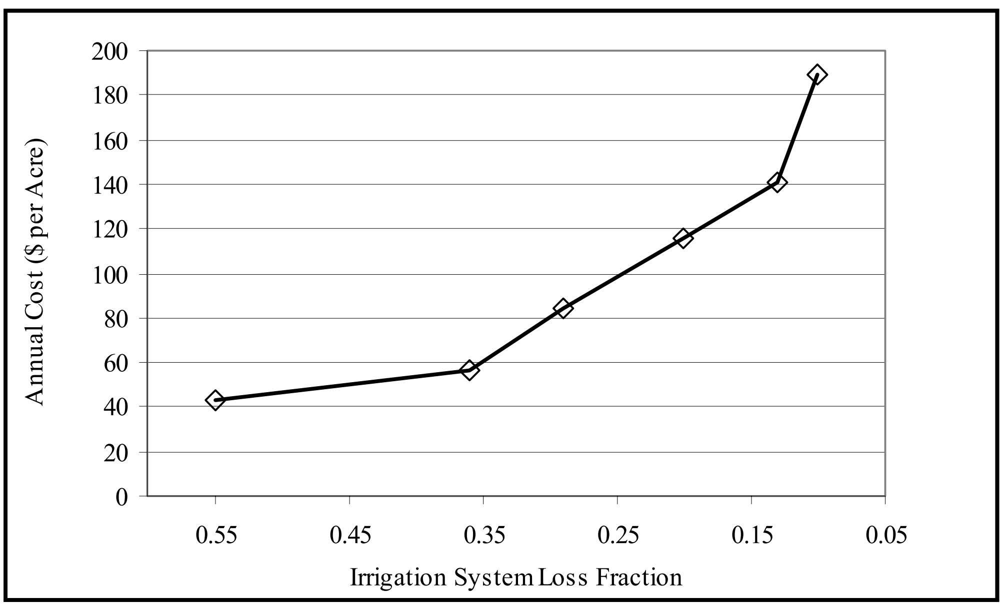
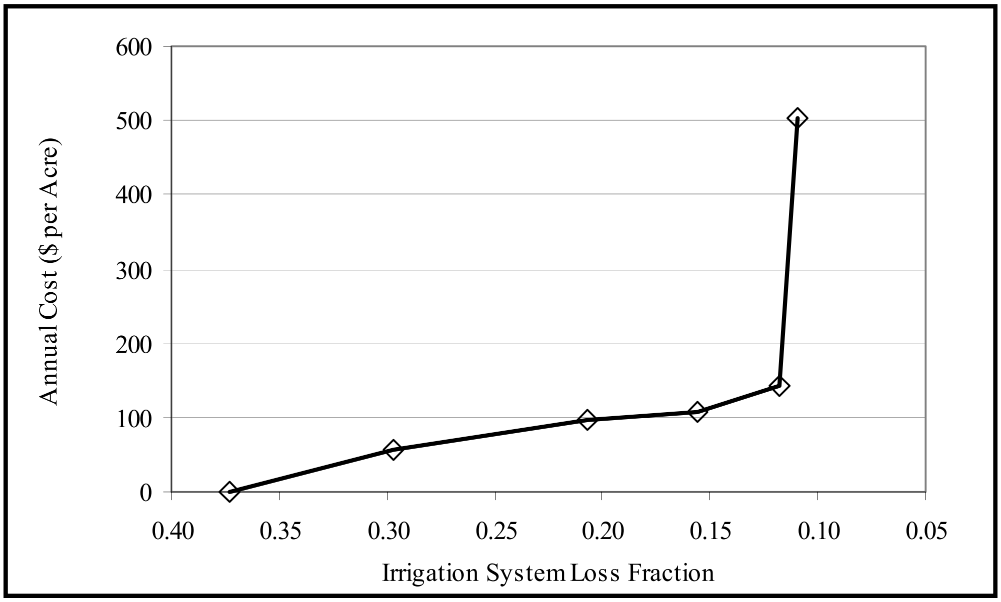
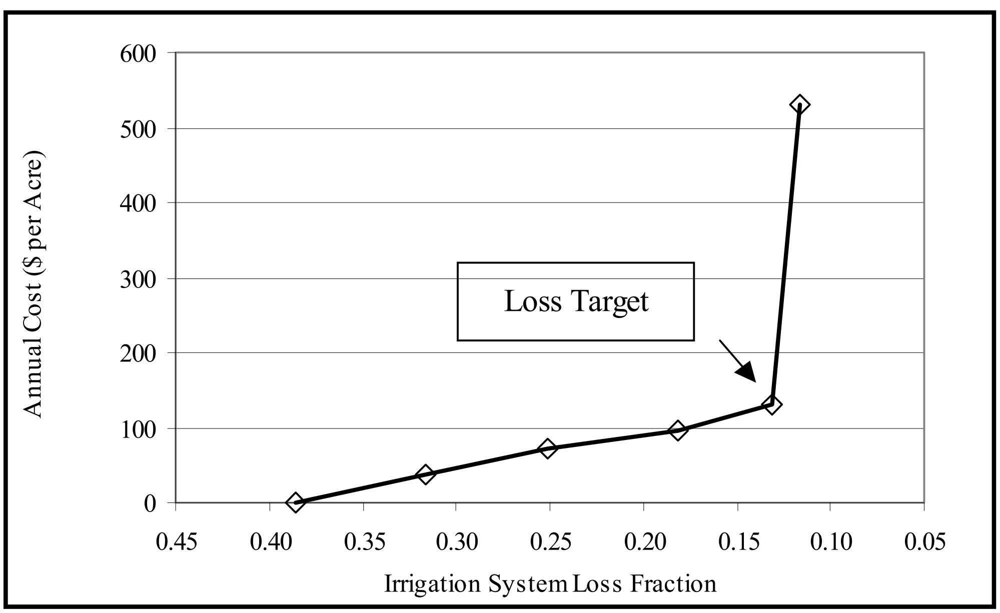


Figure 4.2. Marginal Cost of Farm Irrigation Improvements, Sub-Region 11, Orchards



A target loss fraction was evaluated for purposes of providing example savings (Fig. 4.3). The target loss fraction is defined as the inflection point of the constructed cost curve, the point at which the marginal cost per acre-foot saved begins to increase more rapidly. Reduced losses up to this point can be achieved by adopting a mix of management changes and new hardware, including pressurized systems. Generally, reducing losses beyond this point, though possible, would require adoption of the most expensive irrigation techniques and is not considered economically feasible. The loss fraction at the inflection point varies by crop and also varies

Figure 4.3. Marginal Cost of Farm Irrigation Improvements, Sub-Region 11, All Crops



somewhat based on the systems included in the near-cost-minimizing mix. For must Sub-Regions, the average farm target loss fraction is approximately 0.13, for all crops.

District Level Improvements: The computation of district improvements includes the following two canal loss components:

- Reduction of percolation. These groundwater losses can be reduced by lining or piping the open channels, lining regulating reservoirs, installing seepage recovery systems along the unlined channels and through Conjunctive use of groundwater.

- Reduction of operational spillage. These surface losses can be reduced by a combination of regulating reservoirs and canal automation along main and sub-main supply canals, systems to intercept the operational spill from a series of laterals, regulating reservoirs with automated controls on individual laterals, replacing open laterals with closed pipe laterals and spillage recovery systems that pump water from drains back into the distribution system.

For our analysis all groundwater pumping was assumed to occur on farm. Therefore, the district water delivery ratio would simplify to:

Water Delivery Ratio = (Water Supplied at Farm Turnout) ÷ (Surface Water Diversions)

The analysis of district improvements was based on data from the Imperial Irrigation District/Metropolitan Water District Conservation Program and a feasibility study for an environmental restoration project in the Colombia Basin, Washington. The projected costs of reducing the district delivery losses in terms of the average cost per acre-foot for decreasing the percolation to groundwater and the surface runoff were developed separately and then combined to yield the overall district low and very low loss fractions.

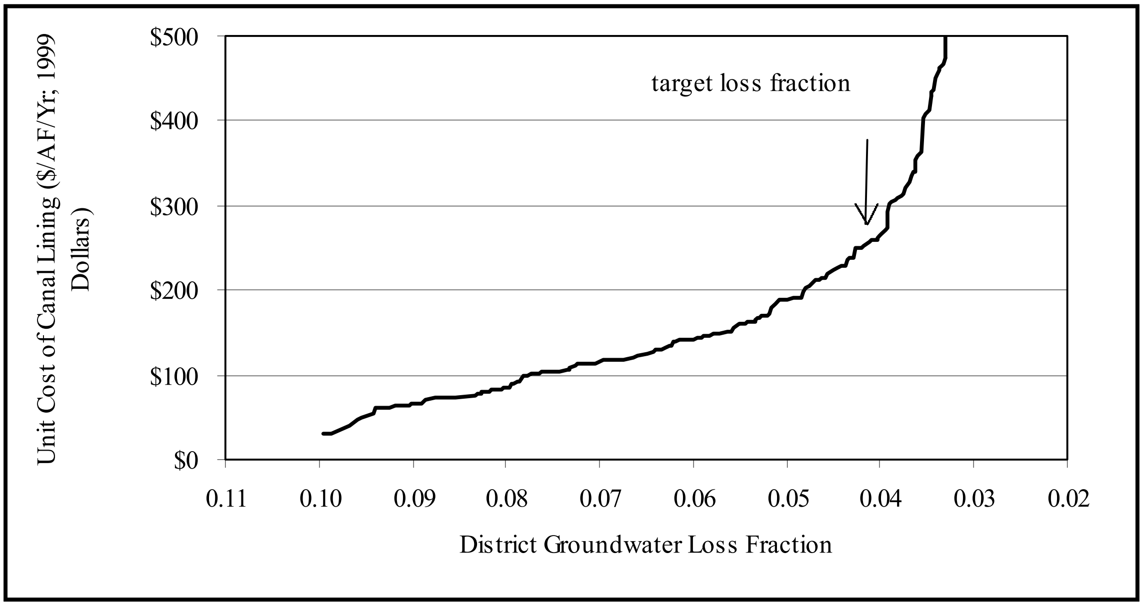
Figure 4.4 shows the costs of reducing percolation to groundwater from district facilities ($/ acre-foot / year), based on canal lining data for 230 separate lateral reaches. All reaches convey between 20 and 100 cfs, and represent a total of 200 miles of canal. The concrete canal lining reduced the percolation to groundwater flows by about 7% of the surface water diversions. We assumed that this is representative of the portion of a typical irrigation district's canal system that would be lined, and that the deep percolation flows in the remaining unlined canals and regulating reservoirs would still be about 3% of the surface water diversions. A 4% district groundwater loss fraction was selected based on the inflection point of figure 4.4.

The potential for reducing surface return from district facilities were based on an analysis of the savings and costs associated with several projects that are designed to reduce operational spill. The cost and performance of the following projects were considered in this analysis:

- Main canal regulating reservoirs: $65/AF in Imperial Valley; $56 and $68/AF in Colombia Basin
- Non-leak gates: $50/AF in Imperial Valley
- Drainage recovery systems: $35 to $125 in Nile Delta
- Lateral Spillage Recovery systems: $124, $146, and $183/AF in Imperial Valley

- Replacing open laterals with closed pipe: $345, $545, and $650/AF in the Colombia Basin (where unlined canals were replaced, roughly $100/AF of these costs could be attributed to reductions in deep percolation.

Figure 4.4. Cost of District Canal Lining, Imperial Irrigation District, California.



These projects represent various combinations of regulating reservoirs, canal automation (along main and sub-main supply canals), spillage recovery systems that pump water from drains back into the distribution system, lateral spill interceptors and converting open laterals to closed pipelines. From an analysis of these projects, the following generalities were assumed:

- The costs of water savings from regulating reservoirs and spillage recovery systems are about $50 to 100 per acre-foot per year;
- The costs of intercepting lateral spills is about $100 to $200 per acre-foot per year; and
- The spill reduction costs of replacing open laterals with closed pipe systems is about $300 per acre-foot per year.

From a review of the overall applied water ratio of these systems and the cost analysis, it appeared that installing mid-level cost facilities, that focus on capturing lateral spills, would reduce the surface return down to about 4%. The surface (4%) and subsurface (4%) target loss fractions described above were combined into an overall target district loss fraction of 8%.

Step 8. Quantifiable Objective

The QO was determined by comparing the quantified Targeted Benefit change (Step 3) with the Achievable Agricultural Potential (Step 7) and selecting the minimum set of values, as follows:

Quantifiable Objectives = Minimum of Quantified Targeted Benefit Change or Achievable Agricultural Potential

SPECIFIC REFINEMENTS TO QOs

The detailed descriptions of QOs 25, 113, and 121 provided below represent three unique computational refinements to the eight common steps discussed previously. Table 4.2 shows which QOs are represented by each of these refinements.

Table 4.2. Representative Quantifiable Objectives

Quantifiable Objectives Described	Quantifiable Objectives or Targeted Benefits Represented	Targeted Benefit
Completed Quantifiable Objectives		
25	7, 18, 25, 33, 46, 53, 63, 71, 88, 107, 127, 144, 157, 164, 168, 176, 180, 184, 189, 193, 197	Decrease nonproductive ET to increase water supply for beneficial uses
113	6, 13, 20, 30, 38, 39, 55, 56, 57, 66, 67, 68, 75, 113, 114, 130, 132, 147	Provide flow to improve aquatic ecosystem conditions
	27, 35, 48, 54, 65, 73, 89, 110, 129, 146, 160	Provide long-term diversion flexibility to increase the water supply for beneficial uses
	106, 167, 183, 188, 196	Decrease flows to salt sinks to increase the water supply for beneficial uses
Priority Targeted Benefits		
113	1, 2, 3, 5, 9, 10, 11, 12, 37	Provide flow to improve aquatic ecosystem conditions
	29, 90, 161, 166, 170, 178, 182, 187, 192, 195, 199	Provide long-term diversion flexibility to increase the water supply for beneficial uses
121	15, 22, 23, 31, 41, 52, 59, 80, 82, 83, 85, 101, 120, 121, 137, 152	Reduce pesticides to enhance and maintain beneficial uses of water
	24, 42, 84, 103, 104	Reduce salinity to enhance and maintain beneficial uses of water
	78, 79, 96, 98	Reduce native constituents to enhance and maintain beneficial uses of water
	81	Reduce nutrients to enhance and maintain beneficial uses of water

Targeted Benefit 113: Provide flow to improve aquatic ecosystem conditions on the Stanislaus River

This section provides a step-by-step description of the methodology used to develop the QO 113: "Provide flow to improve aquatic ecosystem conditions in the Stanislaus River". The same methodology presented for QO 113 was used for all QOs related to flow-timing, long-term diversion flexibility and flows to salt sinks (Table 4.2). Data and computations for QO 113 is provided in Chapter 11 of Appendix A.

Table 4.3 shows Step 1A for QO 113. Each table within a step is designated with an upper-case letter. The first line of Step 1A identifies the data in the table; line two is the source and indicates where the information was obtained. In Table 4.3, the data in the table are the fish flow targets for the Stanislaus River, and the source is the CALFED Ecosystem Restoration Program Plan. Also shown on the source line are data units. For tables that are a product of other tables and data assumptions, the source indicates how the table is generated.

Unless otherwise stated, the data in these tables were computed for each month of the five water year types (critical, dry, below normal, above normal and wet). In addition, a weighted average was calculated based on a proportion of a year type to the total number of water years (69).

Table 4.3. Step 1A for QO 113

Step 1. Quantified Targets

A. Fish Flow Targets for the Stanislaus River (from upper reach to San Joaquin River)
source: CALFED Ecosystem Restoration Program Plan — Thousand Acre Feet

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1) Critical	15.3	13.9	15.3	53.8	53.8	11.9	12.3	12.3	11.9	12.3	14.9	15.3	242.8
2) Dry	16.9	15.2	16.9	53.8	53.8	11.9	12.3	12.3	11.9	15.3	16.3	16.9	253.4
3) B Norm	18.4	16.6	18.4	71.6	71.6	14.9	15.3	15.3	14.9	15.3	17.8	18.4	308.6
4) A Norm	21.5	19.4	21.5	89.1	92.1	47.5	18.4	18.4	17.8	21.5	20.8	21.5	409.5
5) Wet	24.6	22.2	24.6	89.1	92.1	89.1	18.4	18.4	17.8	21.5	23.8	24.6	466.0
Wtd Avg.	18.9	17.1	18.9	69.9	71.0	32.4	15.1	15.1	14.6	16.9	18.3	18.9	327.3

Step 1. Quantified Target

QO 113 is focused on altering Stanislaus River flows at specific times and locations. Step 1 provides quantified target values by month and year type. The quantified targets provide numerical values of "where we want to get to" in terms of the desired flow, in this case, the Stanislaus River downstream of Goodwin Dam. Data are expressed as a monthly water volume. For example, QO 113, Flow and Water Quality on the Stanislaus River, has two quantified targets:

A. Quantified Targeted - Flow regimes requested by the CALFED Ecosystem Restoration Program to restore salmon runs (Step 1A) and,

B. Quantified Targeted Benefit (Water Quality) - Requested flow regimes from the US Bureau of Reclamation to meet salinity requirements at Vernalis on the San Joaquin River (Step 1B).

The values from steps A and B were combined to give the quantified Targeted Benefit for the flow and timing requirements on the Stanislaus River (see Step 1C). These separate flow requirements were combined because the salinity needs are a primary objective of Goodwin Dam releases and must be met before fish flow requirements are considered.

Step 2. Reference Conditions

The reference conditions represent the existing quantified flows. For QO 113, there were no readily available flow data for the targeted river reach, which is the reach of the Stanislaus River between its two largest diversions (Oakdale and South San Joaquin Irrigation Districts), and its confluence with the San Joaquin River. The flow for the targeted reach was estimated by subtracting the historical diversions from the gauged flow at Goodwin Dam, as follows:

Reference Conditions = Stanislaus River Inflow into Sub-Region 11(gauged at Goodwin Dam) – Historical Diversions from Stanislaus River (to Oakdale and South San Joaquin Irrigation Districts)

Or:

Reference Conditions = (Step 2C) = (Step 2A) – (Step 2B)

Step 3. Quantified Targeted Benefit Change

The quantified targeted benefit change is the estimated water flow or quantity change required to obtain the Targeted Benefit. They are the flow volume differences between the quantified Targeted Benefit and the reference conditions for the targeted river reach during each month for each of the five water-year types as follows:

Quantified Targeted Benefit Changes = Quantified Targeted Benefits – Reference Conditions

Or:

Quantified Targeted Benefit Changes = (Step 3A) = (Step1C) – (Step 2C)

Step 4. Area Affected by Targeted Benefit

Data in the CVGSM model is subdivided into 21 sub-regions. However, in some cases the area that affects a Targeted Benefit is only a portion of a sub-region. For example, QO 113 is related to the Stanislaus River, which serves only a portion of Sub-Region 11. Flow path data for the irrigated area supplied from the Stanislaus River is not available. Therefore, it was necessary to estimate the flow path values by proportioning the data from the sub-region by the following ratio for each month and year-type as follows:

Diversion Ratios = Stanislaus River Diversions ÷ Total Sub-Region 11 Stream Diversions

Or:

Diversion Ratios = (Step 4B) = (Step 2B) ÷ (Step 4A)

Step 5. Water Balance Flow Path Elements

Flow paths are the courses that water follows between entering and exiting a given irrigation service area. Physically, the sum of the inflow paths plus (or minus) any changes in soil or groundwater storage must equal the sum of the outflow paths. This relationship is called the "water balance". The inflow paths are rain, surface water diversions, import and groundwater pumping. The outflow paths are evaporation, ET of rain, ETAW, surface runoff, export and percolation to groundwater. The flow path elements cover both farm and district distribution water use.

Step 5 contains data and computations for the flow paths considered in the QO methodology for each month and year-type. Although all flow paths are listed, only the flow paths that can affect the given Targeted Benefit are used in computing the QO. For Targeted Benefit areas that are subsets of a given sub-region, the flow path values were proportioned using the diversion ratios from Step 4 (see Step 4B). For QO 113 (flow in the Stanislaus River), the flow path elements presented in Steps 5A through 5K are computed as follows for each month of each water-year type:

Stanislaus River Service Area Flow Path Value = (Diversion Ratio) x (Sub-Region 11Flow Path Value)

Step 5L, shows the water balance based on Steps 5A through K. Step 5M is the applied water ratio based on ETAW, surface water diversions, import, and export and is determined as follows:

Applied Water Ratio = ETAW/(Surface Water Diversions + Import + Groundwater Pumping – Export)

Or:

Applied Water Ratio = Step 5G ÷ Step 5(B + C + D -E)

Step 5N is the check between existing percolation to groundwater and groundwater pumping. This is presented to provide a check on the sustainability of present groundwater use and a means for evaluating the effects of irrigation system improvements on extraction sustainability. It is determined as follows:

Groundwater (Inflow – Outflow) Check = Percolation to Groundwater – Groundwater Pumping

Or:

Groundwater (Inflow – Outflow) Check = (Step 5N) = (Step 5J) – (Step 5D)

Step 6. Idealized Agricultural Potential

This step provides the maximum amount of water available if irrigated agriculture was perfect, i.e. ETAW is equal to all of the diverted water. The Idealized Agricultural Potential, although impossible to achieve, is computed to provide the theoretical outer bound of the contribution that irrigated agriculture could make toward the Targeted Benefit without reducing ETAW. The Idealized Agricultural Potential, a bookend value, was computed as the sum of all flow paths that can affect the Targeted Benefit.

In some of the CVGSM sub-regions, the export flow is routed through the district distribution system but not delivered to the farm. This action is taken to ensure adequate delivery service. However, this water is also available for making flow and timing changes and is included in the Idealized Agricultural Potential in Sub-Regions 4, 5 and 7.

For QO 113, the Idealized Agricultural Potential is the sum of surface water diversions, import, export adjustment, and groundwater pumping minus the sum of ETAW plus export flows:

Idealized Agricultural Potential = Surface Water Diversions + Import + Groundwater Pumping – ETAW - Export Adjustment

Or:

Idealized Agricultural Potential = Step 5(B + C + D) + Step 6A – Step 5(G + H)

Step 7. Achievable Agricultural Potential

The Achievable Agricultural Potential is the portion of the Idealized Agricultural Potential that could be achieved by implementing practical hardware and management changes at both farm and district levels. The Achievable Agricultural Potential for a service area is based on an evaluation of the relative costs of changing the average estimated applied water ratio (Step 5M), or conversely, a loss fraction from its existing level to an improved targeted level. To move from the existing applied water ratio to the targeted loss fraction requires a combination of management and hardware changes. Farm level changes in management and hardware are based on logical progressions along the marginal on-farm cost curve for each major crop group in the given sub-region.

At the district level, canal, regulating reservoir and drainage system seepage are the primary subsurface flow paths. Lining open channels and reservoirs and converting the open channels to piped distribution or drainage systems can be used to reduce return flows from seepage. Another approach would be to use seepage recovery systems instead of or in combination with canal lining. A district's surface return flow paths are primarily composed of operational spills. Surface spills are typically reduced by various combinations of: main and sub-main canal regulating reservoirs coupled with automation, lateral canal spillage interceptor systems, drainage reuse or recovery systems, and employing more operational labor.

In Step 7A, a farm demand was determined assuming a fixed farm loss fraction. For Sub-Region 11, the loss fraction is 0.13 and the new demand is determined by:

Farm Demand = ETAW/(1 – target loss fraction)

Or:

Farm Demand = ETAW/0.87

Because groundwater pumping was assumed to be a farm level activity, only a portion of the difference between existing farm demand and Step 7A would be met through reduced groundwater pumping. To determine the reduction in groundwater pumping an initial on-farm loss fraction of 0.3 was used, and after system improvements, the new groundwater pumping is:

*Groundwater Pumping after System Improvements = (1-existing loss fraction *(1/1-existing loss fraction – 1/1 – very low loss fraction)* Groundwater Pumping*

Or:

Groundwater Pumping after System Improvements = (1-0.7)(1/0.7 – 1/0.87)* Step 5D*

The water delivery volume required from the district distribution system to the farm using the low loss fraction and the new groundwater pumping was determined by:

Farm Demand not met by Groundwater pumping = Farm Demand (very low farm loss fraction) - Groundwater Pumping (very low farm loss fraction)

Or:

Farm Demand not met by Groundwater Pumping = Step 7(A – B)

Using the farm demand not met by groundwater pumping, the water supply required from the district distribution system using a very low loss fraction was determined by:

Water Supplier Delivery to Meet Farm Demand = Farm Demand not Met by Groundwater Pumping ÷ 1 – Very Low District Loss Fraction

Or:

Water Supplier Delivery to Meet Farm Demand = Step 7C ÷ 1 – 0.08

Using the farm demand, groundwater pumping and district delivery at the very low loss fraction, the Achievable Agricultural Potential was determined as the difference between the existing inflows and the inflows required with the targeted loss fraction by:

Achievable Agricultural Potential = (Surface water Diversions + Import – Export) + Export Adjustment – District Delivery to Meet Farm Demand

Or:

Achievable Agricultural Potential = Step 5(B + C – H) + Step 6A – Step 7D

Step 7F provides a check between percolation to groundwater and groundwater pumping. This is presented as a check on the sustainability of projected groundwater use, and the effects of irrigation system improvements on extraction sustainability. It was determined, assuming that 80% of farm target loss fraction and 50% of the very low district fraction is percolation to groundwater, by:

Groundwater (Inflow – Outflow) Check at target loss fraction = Percolation to Groundwater – Groundwater Pumping

Or:

*Groundwater (Inflow – Outflow) Check at target loss fraction = ((0.13 * 0.8 * ETAW) + (0.08 * 0.5 * District Delivery to Meet Farm Demand)) – Groundwater Pumping (target loss fraction)*

Step 8 Quantifiable Objective

The QO was computed by comparing the Achievable Agricultural Potential (Step 7E) to the quantified targeted benefit change (Step 3A). If the quantified targeted benefit change is less than the Achievable Agricultural Potential then the Targeted Benefit will be fully satisfied for that year-type-month. However, if the Achievable Agricultural Potential is less than the quantified targeted benefit change, the Targeted Benefit will not be fully satisfied and the QO would be equal to the Achievable Agricultural Potential. Step 8A was computed as follows:

Quantifiable Objective = minimum (Quantified Targeted benefit Change, Achievable Agricultural Potential)

Or:

Quantifiable Objective = minimum (Step 3A, Step 7A)

QO 121 Detail: Reduce pesticides to enhance and maintain beneficial uses of water in the Stanislaus River

This section provides a detailed step-by-step description of the methodology used to develop the QO 121: Diazinon concentrations in the Stanislaus River. Where applicable, we have included a set of tables in each step to present the water balance data and numerical targets. Data and computations for QO 121 are provided in Chapter 11 of Appendix A.

Step 1. Quantified Targets
Step 1A provides a description of the constituent of concern for QO 121. The constituent of concerns was described by the following characteristics:

- Behavior in water (soluble or insoluble),
- Whether it is currently used in agriculture (yes or no),
- Timing of application (e.g., dormant spray, pre- and post emergence),
- Persistence in the soil environment (half life),
- Application method (spray or powder), and
- Distribution as influenced by flow paths (e.g., surface water return or percolation to groundwater).

Information from the USEPA was used to determine which crops were treated with a particular constituent. If a constituent was used on a crop, then we assume that 50% of the crop acreage is treated with the constituent.

The characteristics of Diazinon, the constituent of concern for QO 121, are summarized as follows:

- Diazinon is sprayed on orchards during the latter part of the dormant-season and used as a foliar spray on other crops during the growing season,
- Diazinon is soluble and has a half-life of 39 days on surfaces and 14 to 28 days in the soil,
- Diazinon is assumed to reach the Stanislaus River via surface water return flows from agricultural fields and through percolation to groundwater from agricultural fields adjacent to the River, and
- Fifty percent of the acreage on which Diazinon is applied are assumed to drain to the Stanislaus River.

Step 1B provides the regulatory limit for the constituent. For QO 121, Diazinon's regulatory limit, was 0.04 μg per liter. This value was the quantified target benefit for every month and water-year type. It is the numerical value of "where we want to get to" in terms of desired water quality conditions.

Step 2. Reference Conditions
Reference conditions are the existing quantified concentrations of Diazinon. QO 121's target, "Reduce pesticides to enhance or maintain beneficial uses of water", focused on reducing Diazinon concentrations below regulatory limits established by the US EPA. For QO 121, and other water quality Targeted Benefits, reference conditions were the constituent concentrations in

the targeted river reach for each month for each of the five water-year types (critical, dry, below and above normal, and wet). Monitoring of Diazinon in the Stanislaus River was only recently completed, and the data is not comprehensive over year types and months.

The reference conditions for QO 121 are given in Step 2A based on Diazinon concentration data available from USGS Circular 1159 as follows:

- Data for the Stanislaus River during January and February 1998, which was a critical water-year; and
- Data for the Merced River for the 1993 calendar year. From the Merced River data, it appeared that the Diazinon concentrations decrease to less than the regulatory limit of 0.04 μg per liter after peaking in February. We assumed that the same would hold true for the Stanislaus River.

Step 3. Quantified Targeted Benefit Changes

The quantified Targeted Benefit changes are the estimated water quantity changes required to achieve the Targeted Benefit. They are the water quality differences between the reference conditions and the regulatory limits for constituents of concern in the targeted river reach during each month for each of the five water-year types:

Quantified Targeted Benefit Changes = Reference Conditions – Regulatory Limits

Or:

Quantified Targeted Benefit Changes = (Step 3A) = (Step 2A) - (0.04 μg per liter)

In QO 121 the reference condition data is only available for a critical water-year and is below the regulatory limit from March through December. Thus, the quantified Targeted Benefit changes were assumed to be 0.00 from March though December during a critical water-year, so there are no data entries for the other four water-year types in Step 3A.

Step 3B converts the quantified Targeted Benefits change reduction in Diazinon concentration values in Step 3A to reductions in the volumes of Diazinon contaminated irrigation return or rainfall runoff flows to the Stanislaus River. This would be relatively simple if we knew how reductions in return and runoff flows would affect the relative concentrations of Diazinon, but such information is not available. For example, if the Diazinon concentrations were uniform in the return and runoff flows, regardless of the volume of flow involved, then the quantified Targeted Benefit change in volumetric terms for would be:

Volumetric Quantified Targeted Benefit Change = (Concentration quantified targeted benefit change ÷ Reference Condition) x (Idealized Agricultural Potential)

Or:

Volumetric Quantified Targeted Benefit Change = (Step 3A) ÷ (Step 2A) x (Idealized Agricultural Potential)

For example, the quantified Targeted Benefit change in January of a Critical year would be:

Volumetric Quantified Targeted Benefit Change = (0.072) ÷ (0.047) x (Idealized Agricultural Potential)

Step 4. Area Affected by Targeted Benefit
For example, QO 121 applies only to the Stanislaus River service area, which is a portion of Sub-Region 11. Flow path data for the irrigated area supplied from the Stanislaus River were not available, therefore it was necessary to estimate the flow path values by proportioning the data from the sub-region. This was computed for each month and year-type as follows:

Diversion Ratio = (Stanislaus River Diversions ÷ Total Sub-Region 11 Stream Diversions)

Step 5. Water Balance Flow Path Elements
Flow paths are the courses that water follows between entering and exiting a given irrigation service area. Physically, the sum of the inflow paths plus (or minus) any changes in soil or groundwater storage must equal the sum of the outflow paths. This relationship is called the "water balance". The inflow paths are rain, surface water diversions, import and groundwater pumping. The outflow paths are: evaporation, rain evaportranspiration, ETAW, surface runoff, export and percolation to groundwater. The flow path elements cover both farm and district distribution water use.

In Step 5, the flow paths considered in the QO methodology are provided for each month and year-type. Although all flow paths are listed, only the flow paths that can affect the given Targeted Benefit are used in computing the QO. For water quality Targeted Benefits, the affected flow paths include surface water return and percolation to groundwater. Because runoff from rain can potentially be affected by irrigation, this flow path was also considered. For Targeted Benefit areas that were subsets of a given sub-region, the flow path values were proportioned using the diversion ratios from Step 4B.

For areas that are subsets of a given sub-region, the flow path values were proportioned using both the diversion ratios from Step 4A, and the contributing fraction, 0.34, of the area irrigated. For QO 121, the flow path elements presented in Steps 5A through 5K are computed as follows:

Contributing Stanislaus River Service Area Flow Path Value = 0.34 x (Step 4A) x (Sub-Region 11Flow Path Value)

Step 6. Idealized Agricultural Potential
The Idealized Agricultural Potential would be the elimination of all return flow water from irrigated agricultural lands that carry Diazinon to the Stanislaus River. Although the Idealized Agricultural Potential is impossible to achieve, its computation provides the theoretical outer bound of the contribution that practices related to the management of irrigated agricultural lands could make toward the Targeted Benefit without reducing the application of Diazinon.

For QO 121, the Idealized Agricultural Potential would be the elimination of all return flows from irrigated agriculture that carry Diazinon during the time period when Diazinon concentrations in the Stanislaus River exceed the regulatory limits. We assumed that only half of the deep percolation from the area of concern would reach the Stanislaus River during the active life of the Diazinon. Therefore, the quantity of these flows were assumed to be the sum of all runoff from irrigation and roughly 50% of the deep percolation from the contributing areas:

Idealized Agricultural Potential = (Farm Surface Return) + 0.50 x (Percolation to Groundwater)

Or:

Idealized Farm Potential = (Step 6A) = (Step 5I) + 0.50 x (Step 5J)

In addition to the runoff from irrigation applications, runoff from rain, from the irrigated area, during January and February, can contribute to the Diazinon concentration in the Stanislaus River. Runoff from rain could be virtually eliminated during this critical time period by using cultural practices or other means to retain it. This additional Idealized Agricultural Potential is presented in Step 6B, and shows the farm runoff from rain during January and February of a Critical water-year (see Step 5F), which is the only water-year type for which there are reference values.

Step 7. Achievable Agricultural Potential

Since Diazinon is a soluble chemical, we assume that it would occur in the surface runoff from irrigation, but there is no surface runoff flows during January and February because the irrigation season begins in March. However, because Diazinon has a 39-day half-life on soil and plant surfaces and a 14- to 28-day half-life in the soil, deep percolation from rain that falls after Diazinon is applied could carry some of the Diazinon to the River during the critical January and February period. The initial estimate assumes that farm percolation to groundwater on areas adjacent to the Stanislaus River, that represent about half of the contributing area, discharge water contaminated with Diazinon to the Stanislaus River during the critical period. Also, farm runoff from rain on the contributing areas during the critical period is a source of Diazinon in the Stanislaus River. However, please note that the CVGSM data indicates there is very little farm runoff from rain (see Step 5F), but this may not be an accurate representation of the field hydrology.

Possible actions related to irrigation water management to address this QO include retention ponds, furrow dykes, and cover cropping to reduce rainfall runoff. Reduction in late season (October and November) irrigation would reduce farm percolation to groundwater flows. However, it is not possible to quantify the Achievable Agricultural Potential at this time because there is too little data.

Costs that should be considered for the development of the achievable farm potential include the added cost of cultural operations and related management, the risks associated with reducing late season irrigations, and the added cost of any necessary changes in Ag District delivery policies.

Step 8. Quantifiable Objectives

For this example, it is not possible to establish QOs because:

- There is not enough information on the linkage between Diazinon concentrations runoff from rainfall and return flow reductions to convert the quantified targeted benefit changes from concentration to volumetric values; and

- There is not enough data to establish the Achievable Agricultural Potential.

However, it is quite possible that the quantified targeted benefit changes presented in concentration terms in Step 3A could be achieved by reducing the Idealized Agricultural Potentials presented in Steps 6A and 6B by roughly 50%.

WARNING: This analysis is based on only two data points collected in 1998, which was a Critical water-year. This small amount of data is only sufficient to indicate the magnitude of the problem with Diazinon concentration in the Stanislaus River and the means for addressing it.

QO 25: Decrease Nonproductive Evaportranspiration (ET) to Increase Water Supply for Beneficial Uses

This section details the methodology used to develop QO 25: Decrease nonproductive ET to increase water supply for beneficial uses. Some of the standard eight steps are not needed for this QO. An explanation is provided when a step is not needed. Where applicable, we have included a set of tables in each step to present the water balance data and numerical targets. Complete data and computations for QO 25 are provided in Chapter 3 of Appendix A.

Step 1. Quantified Target
The intent of QO 25 is to reduce nonproductive evapotranspiration of the water applied to eligible crops without reducing crop yield by converting the existing irrigation systems to a combination of surface and subsurface drip irrigation systems. Eligible crops included orchards, vineyards and truck crops because their yield and profit potential are considered sufficiently high to support the cost of system conversion. The quantified target is the reduced ETAW volume for the sub-region. The sequence for computing this targeted volume is to first develop Tables 1A, 1B, and 1C using the CVGSM data base:

- Step 1A provides the acres of the eligible crops in Sub-Region 3. We assumed that roughly 30% of eligible crops would be converted to drip in the near future. In Sub-Region 3, this represented approximately 7% of the total cropped area.

- Step 1B provides the average monthly crop ET values, in inches per month, for the vegetable and fruit crops in Sub-Region 3. The total values given for each crop are the ET values for the entire growing season. The monthly totals presented at the bottom of Step 1B are averages weighted by their respective crop areas, in inches per month. The seasonal total of 31.39 inches is the weighted average for all applicable crops in Sub-Region 3.

- Step 1C provides an estimate of the ET resulting from rain for Sub-Region 3 for each month and each of the five water-year types and the overall weighted averages. Some of this ET occurs outside of the cropping season that basically represents evaporation from agricultural lands. Furthermore, in certain months or with certain crops, the ET from rain is in excess of crop ET during the growing season. In these cases, the excess represents additional evaporation that cannot be controlled by irrigation management practices.

- Step 1D provides an estimate of existing ETAW, which was the difference between the monthly weighted average crop ET and the ET from rain for each water-year type, unless the ET from rain exceeded the weighted average crop ET, in which case the existing ETAW was assumed to be zero:

Existing ETAW = (Step 1B) – (Step 1C); or 0.00 if (Step 1B) < (Step 1C)

Since the objective of this QO is to reduce nonproductive crop ET, we assumed that it would be possible to reduce the ETAW to 90% of the existing value by converting current irrigation systems serving vegetable and fruit crops to a combination of surface and subsurface drip irrigation systems. Thus, the weighted average target ETAW for these crops is:

Target ETAW = 0.9 x Existing ETAW monthly values

Or:

Target ETAW = (Step 1E) = 0.9 x (Step 1D)

Step 2. Reference Conditions

The reference condition for QO 25 was the existing ETAW in inches per month for the five water-year types presented in Step 1D. These monthly values contained all of the nonproductive portions of the weighted averages of the existing ETAW for the vegetable and fruit crops in Sub-Region 3, that QO 25 would be expected to address.

Step 3. Quantified Targeted Benefit Changes

The quantified targeted benefit change for QO 25 was the anticipated reduction in nonproductive crop ET that would result from converting the existing irrigation systems on 24,450 acres of vegetable and fruit crops in Sub-Region 3, to a combination of surface and subsurface drip irrigation systems. The quantified targeted benefit change was determined as follows:

Quantified Targeted Benefit Changes = (Existing ETAW) – (Target ETAW)

Or:

Quantified Targeted Benefit Changes = (Step 3A) = (Step 1D) - (Step 1E)

Reducing nonproductive crop ET is exceedingly difficult during relatively high rainfall. As the growing season's initial month, March, and final month, October, generally have higher rainfall, only the months of April through September are included in Step 3A.

The unit values (given in inches) of quantified targeted benefit change in Step 3A were converted to volumes using the anticipated area of system conversion (24,450 acres) in Step 3B using the following formula:

Quantified Targeted Benefit Changes in TAF = 24,450 x (Step 3A) ÷ 12

Steps 4 and 5. Area Affected by Targeted Benefit and Water Balance Flow Path Elements

The only flow paths of concern when dealing with nonproductive crop ET, are ET from of rain and ETAW; therefore, proportioning and developing Steps 4 and 5 are not necessary.

Step 6. Idealized Agricultural Potential
The Idealized Agricultural Potential for QO 25 cannot be established at this time due to lack of adequate data. However, CALFED sponsored research is ongoing in an effort to establish estimates of the possible nonproductive crop ET reductions for various crops and weather conditions.

Step 7. Achievable Agricultural Potential
For Targeted Benefits focused on reducing nonproductive crop ET, such as QO 25, we assume the Achievable Agricultural Potential is the same as the quantified targeted benefit change. Therefore, this step is the same as Step 3B.

Step 8. Quantifiable Objectives
Assuming the achievable farm potential is the same as the quantified targeted benefit change presented in Step 3B, the QO is also equal to the quantified Targeted Benefit change presented in Step 3B. Thus the weighted average QO for the decrease in nonproductive crop ET in Sub-Region 3, or QO 25, is 5.1 TAF per year.

WARNING: This analysis is based on the assumption that by converting existing irrigation systems to a combination of surface and subsurface drip systems, the ETAW is reduced by 10%. As such, any estimated potential reduction in ETAW is speculative and not based on extensive evaluation of existing surface or subsurface drip irrigation systems.

Section V.

Hypothetical Examples of Linkage to Quantifiable Objectives

The 2001 WUE Proposal Solicitation Package (PSP) states that agricultural WUE proposals that incorporate Quantifiable Objectives (QOs) will be given extra weight in the selection process. This section provides a hypothetical example of the proposal format that addresses QOs or priority Targeted Benefits. A proposal may demonstrate a linkage to a QO using a different format than provided here, but this format will facilitate the review by the PSP selection committee.

To provide a single proposal preparation reference, the following proposal formats contain all of the instructions from 'Chapter 10 - Proposal Package Contents' of the PSP along with additional instructions and examples for incorporating QOs. The additional QO instructions and examples are provided in *Italics*.

Example Format for QO 113, Flow in the Stanislaus River

A. COVER SHEET

The Cover Sheet form provided in the PSP should be used to indicate the following:

- Section 1 - Specify: *Check "agricultural project". Check either "individual application" or "joint application" as appropriate.*
- Section 2 - Title: *The title should include the Quantifiable Objective number and abbreviated description. For example:*

  Hypothetical Irrigation District Canal Automation Program to Partially Address CALFED Quantifiable Objectives 113 (Flows in the Stanislaus River)

- Sections 3 through 12: *Fill in as required.*
- Section 13 – Location: *The location should include the Sub-Region according to the CALFED Quantifiable Objective definitions. For example:*

  Hypothetical I.D. Service Area which covers 4,800 irrigated acres on the South side of the Stanislaus River. This area represents a portion of CALFED QO Sub-Region 11.

- Section 14: *Fill in as required.*

B. SCOPE OF WORK

Relevance and Importance

1. Abstract (Executive Summary). Provide a brief description of the project, methods, and objectives. *Your description should include the Quantifiable Objective number and abbreviated description. For example:*

This project will automate canal structures in the Hypothetical Irrigation District to reduce operation spills and improve delivery reliability and flexibility. This project will also partially address CALFED Quantifiable Objective 113 by reducing diversions from the Stanislaus River.

2. Statement of critical local, regional, Bay-Delta, State or federal water issues, which includes an explanation of the need for the project, who wants it, and why. Describe how this project would be consistent with local or regional water management plans or other resource management plans *and how it would address the Quantifiable Objective. For example:*

This project would fill a critical local need for more reliable and flexible agricultural water deliveries. The resulting increased reliability and flexibility will enable growers to irrigate more efficiently because they will be able to more accurately order their desired irrigation duration and rate. This will fill an additional local need of reducing District operations costs.

The proposed project will fill a critical Bay-Delta need of improving in-stream flow and timing in the Stanislaus River. This Bay-Delta need is embodied in CALFED Quantifiable Objective 113.

The proposed project is consistent with the Hypothetical I.D. Water Management Plan which calls for reduced operational spill and improved delivery flexibility. The Hypothetical I.D. Water Management Plan is on file with the Agricultural Water Management Council.

3. Nature, scope, and objectives of the project. Include information about which Quantifiable Objective(s) will be addressed. *For example:*

This project would replace aging canal check structures with automatic structures. The existing structures require excessive labor and maintenance. The proposed new structures would automatically adjust to changing canal water levels and reduce operational spillage. The reduced operational spill will also reduce the amount of rerouted flows that are diverted from and return to the Stanislaus River.

The scope of this project includes replacing 18 existing check structures with… [Include a description of proposed structures including size, type, construction materials, control system, etc.]

The objectives of this project are to reduce labor, increase delivery reliability and flexibility, reduce operational spill, and reduce diversion from the Stanislaus River (CALFED Quantifiable Objective 113.)

Technical/Scientific Merit, Feasibility, Monitoring, and Assessment

4. Methods, procedures, and facilities. Provide information to permit evaluation of the technical adequacy of the approach to satisfy the objectives. *This description should also include a*

description of the extent to which the proposal would address the given Quantifiable Objective. There are two different approaches to describing the linkage of a proposed project to a given Quantifiable Objective: 1) a "QO-specific proposal" and 2) An "action-specific" proposal. Following are descriptions of these two different approaches.

QO-specific: *A QO-specific proposal would include a general description of the proposed actions and a specific proposed contribution to a QO. Because a proposal of this nature would provide a strong linkage to quantified results, it would be weighted higher in the selection process than an action-specific proposal. For example:*

> *The proposed structures will employ a variety of hardware and control systems to meet the objectives listed in Section B3 of this proposal. Through this proposal, Hypothetical I.D. proposed the following reductions in Stanislaus River diversions:*

Quantifiable Objective for HypotheticalI.D. — *Thousand Acre Feet*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1) Critical	---	---	0.0	5.6	4.2	3.2	2.6	2.5	1.0	0.5	---	---	19.4
2) Dry	---	---	0.0	0.0	0.0	0.9	4.1	4.1	1.4	0.8	---	---	11.3
3) B Norm	---	---	0.0	0.0	0.0	0.0	4.6	4.9	2.4	0.7	---	---	12.6
4) A Norm	---	---	0.0	0.0	0.0	0.0	4.7	4.9	2.3	1.0	---	---	12.8
5) Wet	---	---	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.9	---	---	2.1
Wtd Avg.	---	---	0.0	1.5	1.1	1.0	3.3	3.5	1.4	0.7	---	---	12.5

> *The proposed diversion reductions meet a portion of QO 113 (based on Step 8 of the detail for QO 113 listed in "Appendix A, Details of Quantifiable Objectives"):*

Portion of Quantifiable Objective — *% of Quantifiable Objective*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1) Critical	0.0	0.0	0.0	15.0	14.2	11.8	7.6	9.8	15.0	9.7	0.0	0.0
2) Dry	0.0	0.0	0.0	0.0	0.0	15.0	10.0	12.5	15.0	7.6	0.0	0.0
3) B Norm	0.0	0.0	0.0	0.0	0.0	0.0	8.9	9.2	15.0	5.2	0.0	0.0
4) A Norm	0.0	0.0	0.0	0.0	0.0	0.0	15.0	12.4	15.0	8.0	0.0	0.0
5) Wet	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	0.0	7.7	0.0	0.0
Wtd Avg.	0.0	0.0	0.0	15.0	14.2	12.3	10.1	11.1	15.0	7.5	0.0	0.0

Action-specific: *An action-specific proposal incorporates a QO by providing detail about the proposed actions and a rough estimate of the corresponding contribution toward a QO. A proposing entity might prefer an action-specific proposal because they are more comfortable committing to actions (such as canal automation) than to the results of the action (such diversion reduction). A proposing entity would also use an action-specific proposal if they intend to address a Priority Targeted Benefit because Quantifiable Objectives have not yet been established for these benefits. For example:*

> *The automated structures will operate on the principles of downstream control. These structures will react to changes in downstream delivery demand and increase the flow through the check accordingly. The automated structures will reduce district labor by…[provide description of nature of labor reduction].*

Because the proposed structures will react quickly to demand changes, growers will receive greater flexibility and reliability in deliveries and operational spillage will be reduced. Reduced operation spillage will reduce the rerouted flows which is expected to reduce diversion from and return flow to the Stanislaus River. This project will use automated check structures to reduce labor, increase delivery reliability and flexibility, reduce operational spill, and reduce diversion from the Stanislaus River.

5. Schedule. Provide a simple bar chart schedule with tasks, deliverable items, due dates, and projected costs for each task, along with a quarterly expenditure projection. This schedule will form the basis of the required quarterly and annual project fiscal and programmatic reports, should the project be funded.

6. Monitoring and assessment. Describe the monitoring and assessment procedures that will be used to document progress and determine the success of the project. Include information about how the data and other information will be handled, stored, and made accessible. *The proposal should include a description of how the progress toward the given QO will be measured. For example:*

Progress toward the QO will be measured by continuously monitoring Stanislaus River diversions by Hypothetical I.D. and preparing monthly comparisons of the pre- and post-project diversions. These comparisons will be submitted with each progress report. Pre-project diversions will be computed as… [Provide description of how pre-project diversions will be computed]. Following is a summary of pre-project diversions as computed by this method:

Existing Stanislaus River Diversions by Hypothetical I.D. — *Thousand Acre Feet*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1) Critical	1.8	2.2	10.3	40.6	48.6	49.2	48.2	45.1	30.9	7.7	4.4	3.5	292.5
2) Dry	3.1	5.9	10.3	45.4	52.9	59.1	59.5	55.9	33.3	10.5	5.7	2.2	343.8
3) B Norm	1.8	6.6	15.7	47.2	56.8	62.0	62.0	63.0	41.1	10.5	6.2	2.8	375.6
4) A Norm	3.1	4.5	16.6	50.7	59.3	64.3	64.5	62.0	42.0	11.0	8.4	4.0	390.4
5) Wet	6.0	4.8	19.3	53.2	61.4	65.6	68.8	68.7	44.6	9.9	3.9	5.8	412.1
Wtd Avg.	3.0	4.6	14.0	46.8	55.2	59.1	59.5	57.6	37.6	9.8	5.7	3.6	356.5

C. OUTREACH, COMMUNITY INVOLVEMENT, AND INFORMATION TRANSFER

1. Describe outreach efforts to contact and involve participation from people in disadvantaged communities. Describe efforts to extend the benefits of the project to people in disadvantaged communities and develop partner- ships, as appropriate. Describe efforts to involve and extend the benefits of the project to tribal entities in the area.

2. Training, employment, and capacity building potential. Estimate the number and level of people or organizations that are expected to receive training, employment, or capacity building benefits from the project.

3. Describe the plan for disseminating information on the results of the project and promoting their application.

4. Provide a copy of the letter sent to the local land use entity, water district, or other potentially impacted or cooperating agencies notifying them of the proposal.

D. QUALIFICATIONS OF THE APPLICANTS, COOPERATORS, AND ESTABLISHMENT OF PARTNERSHIPS

1. Include a resume(s) of the project manager(s). Resumes shall not exceed two pages.

2. Identify and describe the role of any external cooperators that will be used for this project.

3. Provide information about partnerships developed to implement the project.

E. COSTS AND BENEFITS

1. Budget summary and breakdown. Provide a detailed budget that includes the following line items. (Indicate the amount of cost sharing for each element as well as direct and indirect costs):
   a. salaries and wages
   b. fringe benefits
   c. supplies
   d. equipment
   e. services or consultants
   f. travel
   g. other direct costs including planning, design, construction, maintenance, etc.
   h. total estimated costs; total items (a through g)

For example, see Table 5.1 on the following page.

2. Budget Justification. Provide a brief explanation for the labor costs (including consultants), equipment, supplies, and travel included in the budget.

3. Benefit Summary and Breakdown. List expected project outcomes (the physical changes that will occur as a result of the project) and expected benefits (the value of those outcomes).

a. Quantify project outcomes and benefits. Quantify outcomes and benefits to the degree possible. For example, if the expected outcome of a project is to reduce dry-year demands in a particular region, the amount and value (benefit) of this reduction should be listed if known. Indicate how each quantified outcome and benefit will be shared among the project's beneficiaries. For example, if an outcome will result in an avoided cost benefit for the applicant and/or the project partners, this should be identified as an applicant benefit.

Table 5.1. Sample Budget Summary

Item	*Amount*	*Units*	*Qty*	*Total Cost*	*Units*	*Life (years)*	*Present Value*	*Local Share ($)*	*CALFED Request ($)*
a. salaries and wages									
Maintenance Labor	*2,000*	*$/year*	*18*	*36,000*	*$/year*	*30*	*525,266*	*510,675* [1]	*14,591*
b. fringe benefits	*[None - no indirect cost included with this project]*								
c. supplies									
Completed check structure	*70,000*	*$*	*18*	*1,260,000*	*$*	*30*	*1,260,000*	*156,699* [2]	*1,103,301*
Installed control system	*15,000*	*$*	*18*	*270,000*	*$*	*30*	*270,000*	*0*	*270,000*
Installed telemetry units	*6,000*	*$*	*18*	*108,000*	*$*	*30*	*108,000*	*0*	*108,000*
Installed central control unit	*25,000*	*$*	*1*	*25,000*	*$*	*30*	*25,000*	*0*	*25,000*
d. equipment	*[None]*								
e. services or consultants									
Annual software upgrades	*5,000*	*$/year*	*1*	*5,000*	*$/year*	*30*	*72,954*	*0*	*72,954*
f. travel	*[None]*								
g. other direct costs including planning, design, construction, maintenance, etc.									
Engineering	*150,000*	*$*	*1*	*150,000*	*$*	*30*	*150,000*	*0*	*150,000*
Increase Power	*2,200*	*$*	*1*	*2,200*	*$*	*30*	*32,100*	*29,181* [3]	*2,918*
h. total estimated costs; total items (a through g)							*2,443,319*	*696,556*	*1,746,763*

[1] *Local share of maintenance costs equal to local benefit derived from labor reduction.*

[2] *Local check structure share equal to deferred replacement cost.*

[3] *Local share of power cost equal to deferred pumping cost.*

Identify and delineate quantified outcomes and benefits expected to directly or indirectly benefit the CALFED program. *In addition to a description of the local benefits (if any), this section should refer to Section B4 – Methods, Procedures and Facilities. For example:*

> *This project will reduce labor costs by approximately $15,000 per year. This cost reduction is a local benefit and will accrue to the Hypothetical Irrigation District. This project will also reduce diversions from the Stanislaus River and increase the flow in the Stanislaus River between Hypothetical Diversion Road and Highway 99. The amount of the diversion reduction is listed in Section B4. The increased flow benefits the CALFED Bay-Delta.*

b. For project outcomes and benefits that are not quantifiable, provide a qualitative description of such project outcomes and benefits. List and describe verbally all outcomes or benefits that cannot be quantified at present. One way to describe the significance of a project's non-quantified benefits is in terms of institutional, public, or scientific recognition.

Indicate how each non-quantified outcome or benefit will be shared among the project beneficiaries. Identify and delineate non-quantified outcomes expected to directly or indirectly benefit the CALFED program. *For example:*

This project is expected to increase reliability and flexibility of farm irrigation delivery. Although these benefits cannot be quantified at this time, irrigation scientists and agricultural engineers recognize that they enable reduced district and on-farm labor costs and decreased district and on-farm water losses. Improved reliability can reduce labor by allowing growers to schedule irrigation labor with more certainty and potentially reduce overall labor. Reduced farm labor is a local benefit that will accrue at individual farms.

Improved reliability can also allow growers to schedule irrigations with more optimal rates and durations, both of which are key factors in decreasing on-farm water losses. Decreased on-farm water losses can potentially reduce river diversions and improve water quality through reductions in surface runoff and percolation to groundwater. These represent State-wide benefits.

4. Assessment of Costs and Benefits. Include an assessment that summarizes the costs and benefits of the proposed project. The assessment shall adhere to the following general guidelines:

a. List and explain all major analysis assumptions.

b. Express all benefits and costs in year 2000 dollars. Do not adjust future dollar values for expected general inflation.

c. Convert all costs and benefits to their present value equivalents prior to aggregating them. Use a six percent discount rate.

d. Compile a table showing the present value of the quantified costs and benefits for the applicant, each project beneficiary, CALFED, and any other parties affected by the project. Compile a summary of the non-quantified costs and benefits to the applicant, each project beneficiary, CALFED, and any other parties affected by the project. *For example, see Table 5.2 on the following page.*

The applicant will be required to provide the following items if the proposal is selected for funding. These items are not required to be submitted with the proposal.

F. MATCHING FUNDS COMMITMENT LETTER

Provide an institutional cost-sharing agreement (letter) signed by an official authorized to commit the applicant to all or part of the matching share or a letter authorizing third party, in-kind contribution signed by an official authorized to commit the third party.

Table 5.2. Sample Summary of Quantified and Non-Quantified Costs and Benefits

Item	Amount	Units	Quantity	Total Cost	Units	Life (years)	Present Value	Benefiary
Quantified Costs								
Maintenance Labor	2,000	$/year	18	36,000	$/year	30	525,266	n/a
Completed check structure	70,000	$	18	1,260,000	$	30	1,260,000	n/a
Installed control system	15,000	$	18	270,000	$	30	270,000	n/a
Installed telemetry units	6,000	$	18	108,000	$	30	108,000	n/a
Installed central control unit	25,000	$	1	25,000	$	30	25,000	n/a
Annual software upgrades	5,000	$/year	1	5,000	$/year	30	72,954	n/a
Engineering	150,000	$	1	150,000	$	30	150,000	n/a
Increase Power	2,000	$	1	2,000	$	30	29,181	n/a
Subtotal							2,440,401	
Quantified Benefits								
Reduce labor	35,000	$/year	1	35,000	$/year	30	510,675	Ratepayers (growers) of Hypothetical I.D.
Deferred Replacement of Aging Structures	50,000	2020 dollars	18	900,000	2020 dollars	30	156,699	
Pumping Reduction	2,000	$/year	1	2,000	$/year	30	29,181	
Subtotal							696,556	
Non-Quantified Costs								
[None]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Non-Quantified Benefits								
Increase delivery reliability and flexibility	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Growers of Hypothetical I.D.
Flow for Quantifiable Objective	12,500	AF/Wtd. Avg. year	n/a	n/a	n/a	n/a	n/a	CALFED (Quantifiable Objective 113)
Reduce Stanislaus River diversion	14,700	AF/ Wtd. Avg. year	n/a	n/a	n/a	n/a	n/a	Growers of Hypothetical I.D.
Analysis Assumptions								
Discount Rate is 6%.								
Present Value of costs and benefits are provided in year 2000 dollars.								

G. LETTER OF CONCURRENCE FROM LOCAL GOVERNMENT

The applicant shall provide a letter signed by an official authorized to declare that this project is compatible with existing programs, the local general plan, or other local or regional activities.

H. ENVIRONMENTAL DOCUMENTATION

Prior to the disbursement of any funds, the applicant shall provide documentation that the project complies with environmental laws and regulations and that necessary permits have been obtained. For projects that require environmental documentation, such documentation may tier off of the CALFED Programmatic EIS/EIR, and incorporate appropriate mitigation measures from the Record of Decision. For more information, contact Chuck Vogelsang at (916) 653-2536 or chuckv@water.ca.gov.

For projects that receive federal funding at a future date, applicants shall provide draft environmental documentation to the U.S. Bureau of Reclamation. The Bureau will issue the necessary NEPA documents based on the applicant's draft materials.

Section VI.

Glossary

Agricultural Water Use Efficiency (Ag WUE) Element: CALFED's water management strategy.

Anadromous: fish that spend a part of their life cycle in the sea and return to freshwater streams to spawn.

Conjunctive Use: The operation of a groundwater basin in combination with a surface water storage and conveyance system. Water is stored in the groundwater basin for later use by intentionally recharging the basin.

Core: Ag WUE senior technical advisors: Regional Liaisons, Water Supply, Water Quality, and Biologists (personal communications, 1999 - 2000).

CVGSM: Central Valley Ground and Surface Model, based on hydrologic data taken from USBR, USGS and DWR records, covering an area of approximately 6.76 million acres of irrigated agricultural land over a 69-year period (1922 – 1990).

CVHJVIP: Central Valley Habitat Joint Venture Implementation Plan, April 19, 1990.

CVPIA: Central Valley Project Improvement Act (1999).

Deep Percolation: percolation of (irrigation) water through the ground and beyond the lower limit of the root zone of plants into groundwater.

DWR: California Department of Water Resources.

Evapotranspiration (ET): The quantity of water transpired (given off), retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces.

Evapotranspiration of Applied Water (ETAW): The portion of the total evapotranspiration, which is provided by irrigation and landscape watering.

ERPP: (Draft) Ecosystem Restoration Program Plan (July, 2000).

Groundwater: Water that occurs beneath the land surface and fills the pore spaces of the alluvium, soil or rock formation in which it is situated.

Irrecoverable Losses: The water lost to a salt sink or lost by evaporation or evapotranspiration from crops, a conveyance facility or drainage canal, or in fringe areas of cultivated fields.

NA: Data not available or not applicable.

PEIS: Programmatic Environmental Impact Statement, 1999.

Quantifiable Objective: CALFED developed numerical target benefit, expressed as acre-feet of water and representing CALFED's initial estimate of the practical, cost-effective contribution irrigated agriculture can make to attain the identified benefit, for a specified location and time. Quantifiable Objectives (QOs) are approximations and may be revised as more detailed information is developed.

Quantified Targeted Benefit Change: The estimated water flow or quantity change required to obtain the target benefit; the flow volume differences between the Quantified TB s and the Reference Conditions for the targeted river reach during each month for each of the five water-year types.

Reference Conditions: The existing quantified conditions. For example the USEPA's ambient water quality targets were used for the water quality Targeted Benefits.

RWQCB: Regional Water Quality Control Board.

RWS (ICP): Refuge Water Supply Interagency Cooperative Program (1998).

Targeted Benefits: A listing of CALFED-related goals, developed using existing CALFED goals and stakeholder groups' collaboration, identifying 196 Targeted Benefits believed to have a connection to agricultural water management practices, that articulate specific objectives related to water quality, quantity and in-stream flow/timing.

TBD: To be determined.

TAF: Thousand acre-feet.

SWRCB: California State Water Resources Control Board.

USBR: United States Bureau of Reclamation.

USGS: United States Geological Survey.

Year types (water): critical, dry, below normal, above normal, and wet; data from the CVGSM has been sorted into five water-year types covering an area of approximately 6.76 million acres of irrigated agricultural land.

303(d): List of Impaired Water Bodies, 303(d) (State Water Resources Control Board, 1999).